TWENTY-FIRST ANNUAL REPORT

OF THE

Quebec Society for the Protection of Plants

1928 - 1929

Supplement to the report of the Minister of Agriculture

Printed by order of the Legislature

THE PRINTER TO HIS MOST EXCELLENT MAJESTY THE KING

QUEBEC

1929

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To the Honourable J. L. PERRON,

Minister of Agriculture,

Quebec.

Sir:—

I have the honour to present herewith the twenty-first Annual Report of the Quebec Society for the Protection of Plants, containing the proceedings of the winter meeting of the Society, which was held at Macdonald College, Ste. Anne de Bellevue, Que., on Wednesday, April 17th, 1929.

Included are the papers that were read, and the reports of the officers of the Society.

I have the honour to be,

Sir,

Your obedient servant,

E. MELVILLE DUPORTE,

Secretary-Treasurer.

Macdonald College, Quebec.

QUEBEC SOCIETY FOR THE PROTECTION OF PLANTS

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McOuat, J. E.	Pointe Claire, Que.
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Ménard, J. H.	Forestry School, Berthierville.
Moore, G. A.	159, Querbes Ave., Outremont.
Mougeot, R.	La Trappe, Que.
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Raynaud, Mr.	Berthierville, Que.
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Ryan, W. St. G.	379, Common St., Montreal.
Saunders, L. G.	Univ. of Sas,. Saskatoon.
Savoie, F. N.	Dept. of Agriculture, Quebec.
Simard, J.	Dept. of Agriculture, Quebec.
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Swaine, Dr. J. M.	Entomological Branch, Dept. of Agric., Ottawa.
Tawse, W. J.	Macdonald College.
Taylor, C. F.	Wolfville, N. S.
Tessier, G.	Forest Service, Quebec.
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Vanterpool, T. C.	University of Saskatchewan.
Victorin, Rev. Bro.	University of Montreal, Montreal.
Whetzel, Prof. H.	Cornell Univ. Ithaca, N. Y.
White, R. M.	Entom. Lab. Tressbank, Man.
Whitehead, W. E.	Macdonald College, Que.
Willey, Dr. A.	McGill University, Montreal.
Winn, A. F.	32, Springfield Ave., Westmount.

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Canon, V. A. Huard, D.Sc., Quebec.
Rev. Father Superior, Ste. Anne de la Pocatière.
A. Gibson, Esq., Dominion Entomologist, Ottawa.
Hon. Minister of Crown Lands and Forests, Quebec.
Rev. Father Leopold, D.Sc. Ag., La Trappe, Que.

FINANCIAL STATEMENT 1928 - 1929

Receipts

Balance 1927–1928	$ 224.57
Government Grant	250.00
Interest	1.65
	$ 476.22

Expenditure

Separates	$ 71.75
Secretary's Stipend	50.00
Delegate to Entomological Congress	72.75
Delegate to Phytopath. Society	68.80
Expenses of annual meeting	20.26
Speaker at annual meeting	62.09
Clerical, postage and printing	22.80
Balance in hand	107.77
	$ 476.22

Audited and found correct.

J. G. COULSON,
Auditor.

C. E. PETCH,
President.

E. MELVILLE DUPORTE,
Secretary.

ANNUAL MEETING

The twenty-first annual meeting of the Quebec Society for the Protection of Plants was held in the Biology Building on Wednesday April 17th, 1929. There were forty-eight persons in attendance.

The business meeting was called to order by the president at 1.30 p. m. The minutes of the last meeting and the financial statement for the year were read and approved.

The advisability of holding the next annual meeting in Montreal was discussed by the members and on the motion of Rev. Father Leopold, seconded by Doctor W. Brittain, the meeting voted that this be done.

It was decided to look into the possibility of having a field day during the summer in connection with the summer meeting of the Pomological Society.

The following new members were proposed and elected: Prof. H. Whetzel, Prof. A. H. Gilbert, R. H. Painter, W. St. G. Ryan, W. N. Keenan, C. R. Twinn, F. A. Herman, J. E. Machacek, P. Lagloire, E. Lavallée, C. T. Taylor, J. Howatt, R. Gagnon, N. Beaudoin.

In acknowledgement of the interest he has shown in the society from its inception, Rev. Father Leopold was elected an honorary member.

Following the business meeting there was a symposium on Recent Developments in Insecticides and Fungicides. Those leading in the discussion were:

F. A. Herman:—Some chemical problems involved in the study of insecticides and fungicides.

W. H. Brittain:—Nicotine dusting.

C. E. Petch.—Effect of some sulphur sprays on fruit spur development.

A. D. Pickett.—Derris as an insecticide.

G. H. Hammond.—Sulphur as a deterrent to the oviposition of *Phyllophaga*.

J. G. Coulson.—Seed Treatment.

C. F. Taylor.—Recent developments in the use of sulphur insecticides.

J. Howatt.—Some studies on the use and action of bichloride of mercury as a fungicide.

The papers in the symposium as well as other papers presented by title are printed in the report.

At 7.30 p.m. Dr. E. P. Felt, Director and Chief Entomologist of the Bartlett Tree Research Laboratories gave an address on The Protection of Trees from Insect Pests. Dr. Felt showed a number of lantern slides illustrating the principal shade tree insects and made comments on their habits, life history and methods of control. An interesting portion of his address consisted of historical notes, illustrated with photographs, on some of the older American entomologists.

Dr. H. Barton, Dean of the Faculty of Agriculture, who always, takes a keen interest in the meetings of the society, welcomed the members to the college and moved a vote of thanks to Dr. Felt.

At the conclusion of the meeting Mr. Georges Maheux drew the attention of the members to the great debt which the society owes to the Hon. J. E. Caron, retiring minister of agriculture in the Quebec government, for the generous support which he has always given to the society. The members moved a vote of thanks to Mr. Caron and instructed the secretary to write him acknowledging their obligation to him and their appreciation of the interest he has always shown in the society.

SOME CHEMICAL PROBLEMS INVOLVED IN THE STUDY OF INSECTICIDES AND FUNGICIDES

By Frank A. Herman, Division of Chemistry, C.E.F., Ottawa.

In the analysis of insecticide and fungicide materials special and improvised methods are often necessary due to many of the materials being of a more or less complex composition. The method to be followed must be flexible and readily adapted to the material under examination without impairing the degree of exactitude required.

When the percentage of water-soluble arsenic in some of our common arsenical poisons was under review in fixing "standards" for the Agricultural Pests Control Act, the question was raised that a number of manufacturing plants were not equipped in a manner that would enable them to determine this dangerous component by the official method as defined by the A.O.A.C.

For this reason a series of experiments was conducted to determine a method which would be readily adapted to each plant and yet enable it to keep its products within the limits set by legislation, viz. 1.25 per cent soluble arsenic (as As.) for Paris green; 1.00 per cent for calcium arsenate, and .50 per cent for lead arsenate. The results of this work relating to a survey of Paris green in the Canadian market are shown in the following table.

TABLE 1.—Analysis of Paris Greens for Water-soluble Arsenic. Results Expressed as Metallic Arsenic (As)

Lab'y. No.	Sample	Method I	Method II	Method III	Moisture
91806	A	1.87	1.35	1.42	0.52
91807	B	1.29	0.96	1.08	0.37
91847	C	0.77	0.50	0.67	1.05
91848	D	1.26	0.85	1.02	0.82
91849	E	1.51	0.85	1.02	0.34
91850	F	1.10	0.72	0.99	1.30
91851	G	0.80	0.72	0.72	1.05
91852	H	1.74	1.31	1.46	0.70
91853	I	1.30	0.82	0.91	0.43
91854	J	2.19	1.35	1.53	0.58
91855	K	2.01	1.26	1.38	0.61
91856	L	1.25	0.89	1.13	0.80
92155	M	2.03	1.27	1.48	1.25
92156	N	1.45	1.11	1.28	1.15

1. *Method I.*—As prescribed by the A. O. A. C. official methods of analysis. In this method recently boiled distilled water which has been cooled to a temperature of 32° C. is used. A weighed amount of the sample is added to a litre florence flask, water added to the mark and the flask held at the above temperature for 24 hours, shaking hourly for the first 8 hours. The solution is then filtered and the soluble arsenic determined on an aliquot of the filtrate.

2. *Method II.*—This method is essentially similar to method I with the exception that the recently boiled distilled water was cooled to room temperature (75-79°F), and all operations carried out at this temperature. This method was adopted tentatively as our prescribed method for water-soluble arsenic in Paris Greens and other common arsenical preparations.

3. *Method III.*—This method is similar to Method II with the exception that distilled water, which had not been previously boiled, was used for the digestion.

While on the question of water-soluble arsenic I should like to recall a problem experienced by Mr Kelsall and myself (1) at the Entomological Laboratory, Annapolis Royal, illustrating how the percentage of water-soluble arsenic found following the prescribed method of analysis may be at variance with that actually present in the arsenate and only liberated under atmospheric conditions.

A number of brands of calcium arsenate were examined by the Official Method and found to be very low in soluble arsenic, yet when applied to orchard foliage caused foliage injury, while other brands were found to be measurably higher in soluble arsenic yet did not cause foliage injury. The samples were again examined for soluble arsenic but this time by incorporating in a 3-10-50 Bordeaux mixture and subjecting the mass to carbon dioxide aspiration. The results found by this latter conclusively indicated why the first brands caused foliage injury and the second did not. The percentages of soluble arsenic, as arsenic oxide (As_2O_5), found by the two methods as well as soluble arsenic are shown in Table II.

TABLE II.

Sample	Water-soluble As_2O_5 as determined by official method	Soluble As_2O_5 by tentative method	Total As_2O_5
	p. c.	p. c.	p. c.
Calcium Arsenate A. No. 1	0.33	16.25	41.08
" " A. No. 2	0.52	15.63	43.30
" " A. No. 3	0.40	15.00	41.36
" " A. No. 4	0.35	15.63	41.54
" " A. No. 5	0.42	16.25	43.09
" " A. No. 6	0.38	15.00	44.48
" " A. No. 7	0.42	10.00	44.41
" " B. No. 1	2.00	2.50	42.51
" " B. No. 2	1.49	2.50	43.79
" " B. No. 3	1.96	2.50	43.64
" " B. No. 4	2.13	3.13	43.49
" " B. No. 5	2.24	3.13	43.76
" " B. No. 6	1.59	2.50	46.15
" " B. No. 7	2.50	2.50	45.40

1. Kelsall, A. and Herman, F. A., Scientific Agriculture, Vol. VII, No. 6 February, 1926, p. 207.

The Examination of Poisonous Dusts and Foliage for Electrical Charges.

Recently the question of the electrical charge possessed by the common arsenical dusts has again been revived. In the advertizing literature accompanying an imported brand of calcium arsenate stress was placed on the fact that the arsenate possessed a definite positive electrical charge and that when applied to foliage, due to the opposite or negative charge of the latter, is 250 per cent more adhesive than ordinary calcium arsenate.

The question of adhesiveness will not be discussed at present but will be confirmed this coming summer. The paragraph setting forth the higher percentage of adhesiveness is a verbatim extract from the work of Dr. Moore which appeared in the Journal of Economic Entomology, XVIII, No. 2, p. 282, April 1925.

Electrification.

When a solid or liquid is disintegrated in air, or in any other gas apparently, the particles are found to have become electrically charged. A corresponding charge of opposite sign is found in the air. The sign of the charge upon the particles depends on the chemical nature of the material.

Metallic dust when blown about in the air becomes negatively charged. The dust of acid forming oxides, e. g. silica, becomes positively charged, while that of basic oxides, e.g. lime, becomes negatively charged. With salts the charge depends upon the relative strengths of the acidic and basic ions.

Water always acquires a positive charge, thus when large raindrops in falling, are flattened and ruptured by the resistance of the air the drops become positively charged and the surrounding air acquires a negative charge. When dust is blown about in the air it is found that the charge which apparently resides in the air is really carried by the very fine dust particles which have apparently been formed by the attrition of the larger particles. (Dr. W. E. Gibbs, Chem. & Ind. Feb. 8, 1929, p. 127.)

When Dr. Moore was working on the theory of adherence from the viewpoint of oppositely charged colloids he proved by *cataphoresis* that the common arsenical preparations on which he was working possessed, when wet, an electrical charge negative in character. His summation was that lead arsenate, magnesium arsenate, Paris green, and zinc arsenite were all negative and that the addition of calcium hydroxide did not alter the negative charge of calcium arsenate.

By *endosmosis* he showed that the leaf, when wet, exhibited a negative electric charge.

In order to determine the nature of the charge possessed by some of our spray and dust materials they were placed on the tray of an electroscope and the nature of the charge determined.

The following table shows the scale deflection of the electroscope when poisonous and inert dusts and foliage were examined.

TABLE III.—Scale deflections as shown by the Electroscope when examining inert and poisonous Dusts, Apple, Plum and Cherry Foliage, and Strawberry and Lettuce Leaves. (1)

1. Lime, hydrate	+ 1.2
2. Casein	+ 2.2
3. Calcium caseinate (Spredo)	+ 1.5
4. Calcium caseinate (Kayso)	+ 2.0
5. Lead Arsenate (acid)	+ 2.0
6. Sulphur	— 6.1
7. Sulphur—lead arsenate	0.0
8. Calcium arsenate (D)	+ 3.0
8A. Calcium arsenate (D) collected from duster	+ 2.1
9. Calcium arsenate (D)	+ 1.7
10. Calcium arsenate (C)	+ 1.2
11. Calcium arsenate (G. C.)	+ 1.2
12. Nicotine dust (lime and nicotine)	+ 3.2
13. Paris Green	— 3.0
14. Apple foliage, dry	+ 2.2
15. Apple foliage (after dusting with calcium arsenate No. 8	+ 3.1
16. Apple foliage sprayed with calcium arsenate No. 8	+ 3.0
17. Apple foliage first dusted then sprayed, No. 8	+ 2.4
18. Cherry leaves and blossoms	+ 4.3
19. Leaves on plum branch	+ 3.0
20. Plum leaf removed from branch	+ 1.6
21. Strawberry leaf	+ 2.2
22. Lettuce Leaf	+ 2.2

In viewing the results it will be noticed that a positive deflection of the electroscope was recorded in all cases with the exception of the deflections shown for sulphur, sulphur-lead arsenate and paris green. While the amount of deflection is only relative, it is indicative of the nature of the charge.

The deflections shown for apple and cherry foliage were obtained by placing branches of small trees in the chamber of the electroscope. The trees were growing in large flower pots, thus giving ground contact.

Methods under Review for Spray Residue Removal.

When analysing fruit for spray residue the concentration of the acid or alkali in the wash water will be governed by several conditions such as the spray programme followed and the length of time elapsing between picking and analysis.

For fruit analysed shortly after picking on which the spray residue is not too heavy, a two per cent acid solution (by volume) is enough to remove all residue. The fruit may be placed in a suitable container and agitated occasionally during a period of from fifteen to thirty minutes.

If the spray residue is very heavy, or when oil has been used with lead arsenate, or when a coating of wax has formed on the apple previously to analysis it may be advisable to increase the concentration of the acid to three per cent (actual acid) and also to warm it to a temperature of 70°C.

If the Gutzeit method for determining arsenic is to be followed it is pre-

1. The data shown in this table is the joint work of Mr. Moran, Mr. M. B. Davis and myself, undertaken at the Central Experimental Farm, Ottawa.

ferable to use a diluted nitric acid wash solution of the above concentration, taking an aliquot of the filtered wash solution for a determination.

When using the electrolytic Marsh method either an aliquot or the total wash water is to be evaporated to dryness in the presence of sulphuric acid, the digestion with sulphuric and nitric acids to be continued until, on adding water to the residue a colourless or light straw-coloured solution is obtained. This solution is then placed in the Marsh apparatus, a current of electricity of 5 amperes passed through the solution until all arsine has been evolved. This usually takes from ten to thirty minutes.

Again if it is desired to determine the residue present on the surface alone, in the calyx and stem ends the respective portions are removed, the organic matter destroyed by digestion with sulphuric and nitric acids until the residue when treated with water yields a colourless or straw-coloured solution and is then analysed by either of the methods described.

If the washed apples are to be marketed it is preferable to use a two per cent hydrochloric acid (actual acid) solution.

Using a two per cent nitric acid wash solution the following results were obtained from apples submitted for arsenic residue determinations.

TABLE IV.—Arsenic as As_2O_3, in Grains per Pound of Fruit.

Lab'y. No.	Province	Variety	No. of Sprayings	Date of last sprayings	Nature of Arsenical	Arsenic as Arsenious oxide (As_2O_3 Grains per pound
94657	Ontario	Duchess	2	July 4	Lead arsenate	0.0002
94658	"	"	2	" 16	" "	0.0006
94659	"	"	2	" 4	Cal. "	0.0005
94660	"	"	2	" 16	" "	0.0003
95012	"	McIntosh	2	" 16	Lead "	Trace
95013	"	"	2	" 16	Cal. "	Free
95039	"	King	4	" 14	Lead "	Free
95040	"	Greening	4	" 14	" "	0.0002
95041	"	Snow	4	" 14	" "	0.0001
95042	"	N. Spy	2	" 15	" "	0.0007
95043	"	Greening	2	" 15	" "	0.0046
95044	"	Baldwin	2	" 15	" "	0.0003
95045	"	Greening	2	" 15	" "	0.0003
95214	"	Baldwin	2	June 30	Cal. "	0.0002
95215	"	"	2	" 30	Lead "	0.0003
94756	Quebec	Fameuse	3	Aug. 2	Cal. "	0.0004
94757	"	McIntosh	2	July 15	" "	0.0002
94758	"	N. Spy	2	" 15	" "	0.0003
94759	"	St. Lawrence	4	Aug. 10	" "	0.0003
94760	"	Alexander	2	July 19	" "	0.0022
94583	B. C	McIntosh	4	Aug. 8	Lead "	0.0107
94849	"	"	4	" 8	" "	0.0071
95021	N. S	Gravenstein	2	June 26	Cal. "	0.0002
95022	"	"	4	Aug. 1	Lead "	Trace
95023	"	"	4	June 22	" "	0.0002
95024	"	"	4	July 30	" "	0.0006
95025	"	"	4	" 30	" "	0.0002

It will be noticed that the majority of the samples are practically free from arsenic and that only one sample contained arsenic slightly in excess of the limit allowable (.01 grains per pound).

The Examination of Petroleum Oils for Spray Purposes.

The use of oils for spraying has evolved the question, "Which of the numerous constants now available are of value in deciding whether or not an oil is suitable for spray purposes, or will new constants have to be devised?"

In considering the physical constants which may be of value we have specific gravity or A.P.I. (American Petroleum Institute Scale), viscosity, volatility, distillation, flash and possibly fire point, optical activity, refractive index, melting point, solidifying point, titre test and colour. The chemical constants comprise iodine absorption number, sulphonation value and oxidation number.

Interpretation of Results.

In considering which of the above constants will govern the specifications under which an oil will be purchased for spray purposes I am going to stress the following physical constants; specific grativy or A.P.I., viscosity, volatility, flash point and refractive index, while for the chemical constants, iodine number, sulphonation value, and very slightly, the oxidation number.

Specific Gravity or A.P.I.—The specific gravity of an oil is of value in calculating the density for determining the weight of the oil in bulk and is also a constant capable of imparting information as to the nature of the oils. Paraffin base petroleums usually produce oils having low specific gravity, whereas semi-asphaltic and asphaltic base petroleums produce oils with a higher specific gravity. The constant is of greater value when taken in conjunction with the other constants.

Viscosity.—The viscosity of a liquid refers to its internal resistance or its resistance to flow, and when determined by the Sayboldt Viscosimeter is the time required for a given volume of oil at a specified temperature to flow through a definite size opening. With the MacMichael Viscosimeter which operates on the torsion principle the results are expressed in poises. The amount of twist imparted to a suspended wire, depending on the viscosity of the material is read on a graduated disc attached to the spindle. The readings in degrees of angular deflection, 300 to the circumference, are noted as degrees M. However, by standardizing against solutions of known viscosity in poises the results can be interpreted in poises, i. e. absolute units of viscosity.

Volatility.—This test was usually more or less general in nature, and when conducted conformed to procedure as practiced in the particular laboratory. Recently De Ong[2], [3] defined a method which appears to be readily adaptable for spray oils.

2. De Ong, J. Econ. Ent., XXI, No. 5, p. 697. Oct. 1928.
3. Archbutt, J., Journ. Soc. Chem. Ind., XV, p. 326, 1896.

The test consists in determining the rate of evaporation of the oil from standard grades of asbestos paper, 3 inches square, suspended in an oven kept at constant temperature, ranging from 50 to 100°C. according to the oil fraction used. A weighed amount of the oil sample, usually 0.5 gm. is placed on the sheet of asbestos paper and weighings made every 24 hours until 85 to 100 per cent of the sample has evaporated.

Flash Point.—This is the lowest temperature to which the oil must be heated for the vapour to form an explosive mixture with air. It is an indication of volatile constituents and their relative volativity, but is principally important in determining the fire hazard of the oil.

Refractive Index.—(Zeiss butyro-refractometer).

This physical test usually performed at 40°C affords information in the same direction as the iodine value. It does not however vary between such wide limits as the iodine value for any particular oil so that its indicative value is perhaps somewhat greater The test is very easily carried out.

Iodine Number.—The iodine value is the percentage of iodine absorbed by an oil, fat or wax. It is in fact a measure of the unsaturated bonds present in the substance under examination.

Sulphonation Test.—This is the percentage of oil soluble in 37 N. H_2SO_4 and distinguishes between the aromatic or unsaturated hydrocarbons which are soluble and the inert hydrocarbons which are insoluble.

Oxidation Test.—This test usually spoken of as the Sligh oxidation method is performed by heating the oil at a temperature of 300°C (572°F) for 2½ hours, cooling, filtering and weighing the sludge precipated. The supposed function of a high-temperature oxidation test is to produce in an oil as rapidly as possible, changes of the *same kind* as would normally take place during long periods of active service. It appears probable that the nature of an oxidation test would have to bear some definite relationship to the type of service for which the oil is intended. It is very doubtful if the test run under certain conditions which would give results of use in the evaluation of turbine oils would also be applicable to insulating oils or to spray oils. The decomposition products of an oil heated to 300°C (572°F) are vastly different from those formed when an oil is only subjected to temperatures of 40 to 70°F, the temperature during the process of dormant spraying.

SOME NOTES ON SEED TREATMENTS (*)

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In 1755 Tillet without understanding the true nature of wheat bunt found that a smutty crop was produced by smutted seed, while healthy plants grew from seed free of smut. Later Prevost, in 1807, studied the germination of the spores of the bunt fungus and observed that traces of coppper sulphate, which had already been used to control bunt, prevented their germination. Since that time many other cases of the causal agent of a plant disease carried on a seed or the propagating parts of a plant have been demonstrated and several seed treatments recommended. It is now recognized that seed carrying diseases is often an agent in plant disease dissemination but the great importance and far reaching affects of this are not always fully appreciated. Some of the most serious diseases of plants are carried from year to year on the seed and cause thus enormous losses, much of which could be prevented by proper seed treatments. Excellent discussions of various phases of this problem have been presented by Chen (6), Norton and Chen (26), Orton (27), Orton and Beattie (29), Gentner (14), Munn (25), and Martin (23).

The treatments for grain smuts are among the most successful disease control measures yet devised in the field of plant pathology. While most seed treatment studies have been concerned with grain smuts, several other cases where such treatments have proven more or less beneficial have been found. The following list includes a number of examples among seed transmitted diseases:

1. *Cereals:*—

Helminthosporium blight of wheat—Helminthosporium sativum P. K. and B.
Black chaff of wheat—Bacterium translucens undulosum S. J. et R.
Wheat scab—Gibberella saubinetii (Mont.) Sacc.
Nematode disease of wheat—Tylenchus tritici (Stein.) Bast.
Fusarium foot and root-rots—Fusarium spp.
Halo blight of oats—Bacterium coronafaciens Elliott.
Leaf spot of oats—Helminthosporium avenae Eidam.
Stripe disease of barley—Helminthosporium gramineum Rab.
Net blotch of barley—Helminthosporium teres Sacc.
Bacterial blight of barley—Bacterium translucens J. J. et R.
Anthracnose of rye, wheat, etc.—Colletotrichum cereale Manns.
Ergot of rye—Claviceps purpurea (Fr.) Tul.
Seedling blight of corn—Diplodia zeae (Schw.) Lév.
Bacterial wilt of corn—Aplanobacter stewarti (E. F. S.) Mc. C.

* A paper read before a symposium on fungicides and insecticides.

2. *Field crops:—*

Root and seedling blight of sugar beets—Phoma betae Fr.
Root rot of peas—Mycosphaerella pinodes (Berk. and Blox.) Stone and Ascochyta pinodella N. sp.
Stem rot of clover—Sclerotinia trifoliorum Erik.
Anthracnose of cotton—Colletotrichum gossypii South.
Flax wilt—Fusarium lini Bolley.
Anthracnose of flax—Colletotrichum linicolum Peth. and Laf.
Wildfire of tobacco—Bacterium tabacum Wolf and Foster.

3. *Vegetable crops:—*

Cercospora leaf spot of beet—Cercospora beticola Sacc.
Bacterial blight of beans—Bacterium phaseoli E. F. S.
Anthracnose of beans—Colletotrichum lindemuthianum (Sacc and Magn.) Bri. and Cav.
Mosaic of beans.
Black rot of cabbage and other crucifers—Bacterium campestre (Pammel) E. F. S.
Black leg of cabbage and other crucifers—Phoma lingam (Tode) Desmazieres.
Cabbage yellows—Fusarium conglutinans Woll.
Alternaria leaf spot of crucifers—Alternaria brassicae (Berk.) Sacc.
Early blight of celery—Cercospora apii Fres.
Late blight of celery—Septoria apii (Br. and Cav.)Rostrup.
Bacterial blight of celery—Bacterium apii Jagger.
Anthracnose of cucurbits—Colletotrichum lagenarium (Pass) E. and H.
Angular leaf spot of cucurbits—Bacterium lachrymans Sm. and Bryan.
Corynespora leaf spot of cucurbits—Corynespora melonis (Cooke) Lindau.
Fusarium wilt of cucurbits—Fusarium sp.
Fruit and leaf spot of egg-plant—Phomopsis vexans (Sacc. and Syd.) Harter.
Anthracnose of pepper—Colletotrichum nigrum E. and H.
Bacterial spot of pepper—Bacterium vesicatorium Doidge.
Black spot of pepper—Alternaria sp.
Cercospora spot of pepper—Cercospora capsici Heald and Wolf.
Bacterial spot of tomato—Bacterium vesicatorium Doidge.
Grand Rapids disease of tomato—Aplanobacter michiganense, E. F. S.
Fusarium wilt of tomato—Fusarium lycospersici Sacc.
Macrosporium blight and rot of tomato—Macrosporium spp.
Damping-off of seedlings.

4.—*Ornamentals:—*

Fusarium wilt of asters.—Fusarium conglutinans Woll.

In a test for seed disinfection by using dip dust on 29 different flower seeds, 21 showed an increase in stand, 1 showed no effect and 7 were reduced in germination, Orton (28).

Since considerable value from a chemical seed treatment may be due to the protection given the seedling plant against soil borne organisms, benefits

derived from treating seed do not necessarily indicate control of a seed-borne parasite. Identification of the parasite in or on the seed is one of the surest proofs of a case of seed transmission of a disease. Peyronel (31) in a study on the effect of soil sterilization upon the normal flora of the roots of wheat found that unsterilized soil gave 96.45 per cent infection of roots and complete sterilization gave only 10.25 per cent infection, and increased yield by 219 per cent over the control. It is obvious that any factor such as a seed treatment which reduces this infection will tend also to enhance yields. Orton (28) states that certain dust disinfectants applied to the seed protect seedling peas from rhizoctonia in the soil.

The method of seed treatment used in any particular case is determined largely by the type of association between the seed and the agent causing the disease. Four types of association are found: (1) pathogene accompanying the seed as in ergot of grasses. *Claviceps purpurea*, small sclerotia of Sclerotinia trifoliorum in clover seed, and nematodes in infected wheat grains. (2) Pathogene borne on surface of seed as covered smuts of cereals, Phoma betae on beet "seed" and Bacterium visicatorium on tomato seed. (3) Causal agent borne internally as with loose smuts of wheat and barley, Colletotrichum lindemuthianum in beans, Colletotrichum gossypii in cotton seed, Phoma lingam in cabbage seed, Phytophthora phaseoli in lima bean seed, bean and clover mosaic viruses, and cucumber mosaic virus in wild cucumber seed. (4) Pathogene carried both externally and internally as in oat smuts, loose smut of barley, Bacterium phaseoli causing bacterial blight of beans, Septoria apii infecting celery seed, Aphlanobacter stewarti causing Stewarts, sweet corn disease and Phomopsis vexans on the egg-plant. The majority of seed borne troubles seem to be carried totally or partly internally.

In some cases the pathogene accompanying the seed can be separated out quite conveniently by some rather simple means. Thus some value is obtained by floating out on water bunted grains from wheat seed. Ergots in grain, sclerotia in clover seed and nema infected grain can be separated with a salt solution of the proper concentration. Cleaning of seed by means of a fanning mill removes light seeds which are more apt to be carrying disease than the heavier seed (15). Repeated tests at Macdonald College have given heavier oat smut infections with light seed than with heavier seed of the same variety. Taylor (41) reports a similar result with loose smut of wheat. There were three and five times as many infected heads in the plants grown from the small seed as there were in those from the larger seed in a test carried over two different years. If the diseased seed shows some marked difference in appearance from the healthy, then it is possible to separate by seed selection the healthy from the infected seed as in the case of bean anthracnose in varieties in which the seeds are white or only slightly colored.

A few cases are known in which the seed has greater viability than the pathogene. Proper storage of such infected seed for a time long enough to kill the parasite without damaging the seed will give excellent control. Thus storage of celery seed for three or four years frees it of late blight—Septoria apii. Likewise bacterial blight of beans is controlled by using seed two or three years old (20).

The most difficult problem is presented by those cases where the causal agent is borne internally. The only successfull method so far devised is the cumbersome and difficult hot water treatment designed by Hensen in 1887-1889. Hot air treatments have been tried without particular success (2).

Much success has been obtained by the use of some chemicals as dusts or steeps for the treatment of various seeds. This method depends upon the action of some substance which will be toxic to or prevent the germination of the causal agent such as a fungous spore borne on the surface of the seed without harming the seed itself. Investigators have experimented with quite a number of widely separated chemicals, but only copper sulphate, copper carbonate, formalin, some organic mercury compounds, and mercuric chloride have been used to any great extent. However, sulphur as a dust has been found by a number to give good control of bunt; hydrogen peroxide has been recommended in England for the disinfection of celery seed infected with Septoria apii; carbolic acid steep has been used in Germany for the control of Phoma betae on beet seed; and Archibald (1) found sulphuric acid useful on cotton seed to reduce black arm disease. Plaut (32) found that a five per cent solution of super-phosphate for thirty minutes controlled bunt of wheat while Straib (40) finds that fertilizers are not useful for bunt control.

Copper sulphate—the use of this material in solution as a seed disinfectant was first introduced by Schulthuss in 1761 for wheat against bunt. Since that time it has been used upon other grains for smuts but the serious injury that it often causes to the grain makes it a rather doubtful treatment to employ. For this reason it is now only recommended for wheat. Sampson and Davis (36) have reported excellent control of wheat bunt from the use of dehydrated copper sulphate as a dust.

The spore wall seems to adsorb some of the copper which prevents germination and washing this out allows the spore to germinate (3). The post-treatment with milk of lime no doubt forms insoluble copper precipitates, which remain in the spore wall longer, and this may explain why liming has often increased efficiency of treatment. The copper sulphate solution is apparently most effective at a temperature near the optimum for spore garmination—See Martin (23).

Copper carbonate.—One of the most outstanding recent advances in plant disease control was made when Darnell-Smith (11), in 1917, described the use of copper carbonate as a dust disinfectant for bunt of wheat. This material has since been used in a number of countries with wonderfull success. It was first used in United States in 1920 and is now the disinfectant used almost entirely for bunt control in North America. Taylor (42) reports that the saving in wheat due to the use of this dust was at least 5,000,000 bushels in the United States in 1925. Most workers have found it inefficient against covered smut of barley or oat smuts excepting with hull-less varieties. However, absolute control of smut in hulled oats has been obtained with copper carbonate (34). It has been found more or less useful for some other seeds such as beets.

Formaldehyde.—This was recommended first by Geuther in 1895 for the disinfection of cereal seed. Since then it has been used more or less as a general seed disinfectant. Little is known concerning the action of formaldehyde upon the spore and it has been assumed that it unites with the albuminoid part of the cell. Recently it has been shown that dusts made by absorbing formalin in charcoal, etc., are very useful as seed treatments for cereals (37). One such product known as smuttox is now on the market.

Bichloride of Mercury.—It is used to some extent for sterilization of vegetable seeds—(1-1000, 5-20 minutes). It has been used chiefly as a disinfectant for seed potatoes where it seems more useful than formalin. It is useful against Fusarium on rye and oat smuts.

Organic Mercury Compounds.—These materials were first used in Germany about 1912 and have come into great prominence within the last few years. Out of a large number tried in America most have been useless while a few have shown particular value such as:

Chlorphenolmercury: Chlorphol, semesan, uspulun, tillantin R. and nu-green.
Cyancresolmercury: Germisan.
Hydroxymercuricresol: Semesan Jr.
Orthonitrophenolmercury: Corona 620.
Hydroxymercurinitrophenol sulphate: Bayer dust.
Ethylmercurichloride: Ceresan.

All contain very high amounts of inert materials. They are used either as steeps or dusts. These substances are not nearly so toxic as a rule as mercury salts to animals. It is assumed that it is the mercury which is the toxic part of these materials, but it is highly probable that the different groups to which the mercury is attached determines to a considerable extent the fungicidal value. The general finding seems to be that they are often as effective as

copper carbonate for controlling of bunt, and excellent for barley seed when used as a steep. Ease of application and economy, however, favour copper carbonate for bunt. Ceresan which is a very recently developed product and has not been subjected to a great deal of experimentation, however, gives promise of being excellent for the control of covered smut of barley, stripe of barley, loose smut of barley in certain six-rowed varieties, oat smuts and bunt. These products have given very good results in many cases with vegetable seeds.

Merko.—This is a new dust containing metallic mercury 3.5 per cent and inert material 96.5 per cent, which has given excellent results on corn seed in a few tests.

At first though it might seem that any fungicide would act as a seed disinfectant for an externally borne parasite. The problem, however, is not so simple as that for a number of examples can be given where a substance may be highly toxic to one fungus and not at all or little to another. Thus, many materials of definite bactericidal properties such as trade disinfectants have been of little value towards seed-borne organisms. Formalin is ineffective against seedling diseases of beets while semesan dust, uspulun steep, copper carbonate and bichloride of mercury reduced infection (9). The modified hot water treatment controls barley smuts but not stripe disease of barley (10). A combination treatment is here needed. Copper sulphate does not control stripe disease of barley (*Helminthosporium graminium*) or Fusarium diseases of cereals as well as organic mercury compounds (45). Copper carbonate, sulphur and formalin give unsatisfactory control of Helminthosporium sativum on barley and wheat while organic mercurials give good results (35 and 38). Dust treatments on corn and sorghum have given more consistent results than liquid steeps of the same materials (18). In seeds treated with uspulun with partial success for complete sterilization Aspergillaceae were prominent while spore-bearing bacteria were more in evidence from seeds treated with silver nitrate (33). Sulphur and formalin have failed to control seedling blight of oats while organic mercurials do (39). Liquid treatments are unsatisfactory for peas or beans as the seed coats are loosened and often removed.

The formalin, copper sulphate and hot-water seed treatments have proven very often unsatisfactory from the standpoint of seed injury. Several factors influence the effects of the treatment on the seed. Increasing time of the treatment temperature and concentration of the solution tends to increase injury. There is usually a maximum dosage that the seed can withstand. The toxic effect varies with the kind or variety of seed and the treatment. Thus according to Pringsheim (33), silver nitrate in a test on a large number of seeds has been found to be highly toxic to the Cruciferae, which were not harmed by uspulum. Bromine was almost uniformly injurious to seeds but did less harm

to the seed coats of beans than several other liquid treatments. Lima bean seeds dusted with mercurials may germinate well but give poor plants while string beans are not mercury sensitive. Tomato seeds have been found to be sensitive to mercury disinfectants and the plants resistant to mercury sprays, while cucumber and cantaloupe seed were resistant to injury from mercury and copper treatments (8). Beet seeds have been found to be more resistant to mercury compounds than to formalin. Liquid treatments loosen or remove the seed coats of beans and peas and so are unsatisfactory on these seeds. Wheat is more resistant to copper sulphate injury that barley or oats. Varieties of wheat vary in their susceptibility to formaldehyde injury. Due to the protection of the hull, hulled oats are more resistant to formaldehyde than hull-less varieties. Any variety of seed varies in its susceptibility to injury depending upon conditions under which the seed is grown and stored. Variation in toxic effects may also be due to variation in composition or impurities in the chemical used. It has been claimed that a natural reaction in the hot water treatment renders the grain very susceptible to injury while acidified water (pH-4) reduced injury (30). Formalin has caused much greater damage to grain at low seed bed temperatures while the reverse was true with mercury compounds (12). It has often been observed that formalin causes great damage to grain if soil is very dry immediately after planting. The pericarp of grains is practically impervious to copper and to a large extent against formalin. When, however, the pericarp is scratched or broken these chemicals penetrate and so injury is increased and is largely proportional to the amount of broken pericarp (17). Grain with injured pericarp is also more apt to be injured in the hot water treatment (44). The amount of pericarp injury will depend upon such things as conditions of growth and maturity of seed at threshing and method of threshing. The dust treatments properly used apparently do little damage to seeds.

Recent studies by Braun (4 and 5) and Hurd (16) as to methods of reducing injury to grain due to formalin have shown that keeping the grain wet after treatment, or rapid drying of the grain reduces post treatment injury. Planting in dry soil increases injury often excessively while wet soil reduces it. The essential feature of this seems to be to provide conditions which prevent the formation on the seed of paraformaldehyde which is very toxic. Presoaking the seed in water, which seems to reduce hardening of the pericarp by formalin and reduces the concentration of the chemicals diffusing into the seed, has reduced injury to the seed and increased the germicidal value by probably stimulating the parasite into vegetative activity. The pre-soaked seed retains the formalin for a shorter time than the unsoaked seed. The hardened pericarp perhaps damages the radicle during germination. Washing of the seed with water reduces post treatment injury with formalin or copper sulphate. It has been suggested that the value of a lime treatment after copper sulphate is due to the formation of insoluble copper precipitates, making the copper less injurious to the seed and

the copper salts clinging to the seed protecting the seedling later on against soil borne organisms. Storing of the grain in sacks after copper sulphate treatment increases the injury to the seed (3). Seed of low vitality is particularly subject to injury by seed treatments.

The standardized dust treatments do not seem to cause injury and in fact numerous claims have been made that they produce stimulation. At first strong claims were made for this stimulating effect in favour of the organic mercury compounds, but carefully conducted experiments in recent years in Europe and America have in most cases shown no increases in crop due to growth stimulation (32). Increases in germination and yields have been explained in most instances by the fact that these materials clinging to the seed protect the seedlings from soil borne parasites. However, a few have found increases in yield greater than could be explained by this protection and this is thought to indicate a possible stimulatory effect (7).

The ideal chemical for seed disinfection is one which is toxic to the pathogene under the conditions of the treatment and not toxic to the seed. The minimum concentration of the substance, which kills the spore and the maximum concentration that the seed can tolerate, are very important and should be known for all seed treatments. This is a line of work that is recently being done in Germany (13) and holds out promise of forming a basis for the standardization of our various seed treatments. A knowledge of these two concentrations of materials and proper time of application would indicate the conditions that would give maximum control with least injury. Unsatisfactory materials could be easily and quickly eliminated.

The season of the year may have an important bearing upon the value to be obtained from seed disinfectants. As a general rule it has been found that the stand and yield of early planted spring crops are definitely increased, while the results may not be so noticeable with the same crops planted later, when conditions are more ideal for germination. Dust treated seeds allow for earlier spring planting, as in general such seed has some protection under adverse conditions during or just after planting against both seed and soil borne parasites. So dusted seed can remain longer in cold soils than untreated seed. Even in case of disease free seed there is often a marked benefit from control of soil, borne parasites which cause seedling troubles. In this way dipdust applied to pea seeds protected the seedlings against infection in rhizoctonia infested soils and increased stand over the same seed untreated and planted in unsterilized soil (28). This must be taken into consideration in evaluating the effect of certain seed treatments or in estimating any stimulatory property.

It is evident that the effectiveness of a dust may be influenced by temperature and rainfall after planting. Heavy rain washes away the dust and, on

the other hand, very dry conditions during germination have reduced fungicidal value of dusts (22). Extremes of soil reaction have not been found to effect their action (22). Seed of low vitality is benefitted most by dust treatments.

Copper carbonate does not deteriorate with age while the mercurials show this tendency. Variations in results are often due to variability in the chemical constitution of the disinfectant and the proper use of inert materials in dusts demands strict attention.

Dusted grain is protected against weevils, rats and mice.

When one considers the number of factors involved in seed treatments it is not at all surprising that great variations in results are obtained and exist in the literature on this subject. This is a more difficult problem than fertilizer experiments, as here one has to consider the effect of the chemical or treatment on two or more organisms.

The trading in seeds between countries introduces a definite international problem which has been discussed by Orton (27) and Orton and Beattie (29). The scope of seed inspection and certification should be enlarged to protect more effectively the grower, if at all possible, from buying diseased seed. The difficulty here is in the fact that no reliable or practical method has been found for determining most seed infections (14).

This important phase of plant disease control offers many baffling problems crying for solution. The idea in the minds of a number of workers has been to find some universal treatment for all seeds and all seed borne troubles. No method approaching this goal has yet been found. From the standpoint of ease of application and economy the two most suitable materials known are sulphur and copper carbonate used as dusts and are to be recommended wherever effective. Since a treatment may be specific in its action towards various seed borne parasites, a combination treatment may be required when a seed carries more than one pathogene.

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RECENT DEVELOPMENTS IN THE USE OF SULPHUR FUNGICIDAL SPRAYS

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Sulphur has long been known to be toxic to fungus spores and therefore its uses as a fungicide have been many and varied. Pliny first recommended the burning of sulphur in orchards as a control measure, but perhaps the most widely diversified forms have been used as sprays, both insecticidal and fungicidal, against orchard pests.

Lime-sulphur.

The first authentic record of the use of lime-sulphur as a fungicide dates back to that made by Grison of France in 1851. It was later developed as a sheep dip in California and was first used as a spray on apple trees against the San Jose scale in 1886. About 1900 it came into use as a summer spray when applied in weak dilutions. In 1909 it was generally used in Nova Scotia as a summer spray, but with the advent of the coarse driving spray from spray guns the mixture began to cause considerable foliage injury which led to a general decrease in its use.

In recent years the extreme injury caused by Bordeaux mixture in the presence of the European Apple Sucker and the russetting of the fruit of certain varieties by the same spray has led to a tendency to return to sulphur sprays or dusts. In view of this tendency, considerable investigation has been carried on in Nova Scotia and elsewhere in order to find a safe, yet effectual sulphur spray.

Lime-sulphur Aluminium Sulphate Mixture.

A very promising spray developed in recent investigations has been the lime-sulphur aluminium sulphate mixture with calcium arsenate. Aluminium salts first came into prominence as fungicides about 1920 in France, Villedieu proposing the substitution of aluminium sulphate and lime for Bordeaux mixture. Kelsall (3) in 1922 reported the results of experiments with aluminium sulphate and lime in which this mixture had some action, though much more feeble than Bordeaux mixture against apple scab. However in this mixture white arsenic was satisfactorily used as an insecticide.

As an outcome of these investigations, the lime-sulphur aluminium sulphate mixture with calcium arsenate has been devised. This mixture has been

under experiment for several years and used under general orchard conditions for at least two years.

Kelsall in 1929 (4) reports on the results of experiments with this mixture as compared with other sprays. The lime-sulphur sprays and Bordeaux sprays were considered together and termed standard spray materials. By this means a comparative test of the aluminium sulphate mixture with calcium arsenate *versus* standard spray materials was obtained in twenty-five experiments. The average percentage of apples affected with scab in these twenty-five experiments was as follows:

Standard Spray materials	22%
Lime-sulphur aluminium sulphate with calcium arsenate	25.6%
Check plots	94%

In taking these records the slightest evidence of scab on an apple led to that apple being classed as scabbed. In commercial practice not more than half of these would be considered spotted. The experiments were all carried out on McIntosh Red, Fameuse and Stark which are very susceptible varieties, and in orchards which were known to be heavily infested with scab. From these results it may be seen that the lime-sulphur aluminium sulphate mixture with calcium arsenate is very little if any lower in fungicidal value than the standard spray materials.

As an insecticide against biting insects this mixture has been found equal to the standard spray materials with stomach poison added. In combination with nicotine it is quite equal to other standard sprays combined with this poison.

The apples from plots treated with the aluminium sulphate mixture are of good appearance, being smooth and shiny with the full development of colour in no way lessened. In several of the experiments the apples from aluminium sulphate plots have been much superior to those from the Bordeaux plots where there is some tendency towards russetting and a poorer colour. In the majority of cases the fruit from the aluminium sulphate plots and from the lime-sulphur plots have been about equal in finish, though in a few cases the apples from the lime-sulphur aluminium sulphate plots have been somewhat superior to those on the plots sprayed with straight lime-sulphur.

On the foliage no typical lime injury has occurred on plots treated with the mixture, while the foliage on these plots has been noticeably larger and greener than on the lots sprayed with straight lime sulphur. Kelsall (4) reports, "A

comparison of all our experiments in which aluminium sulphate mixture was compared with straight lime-sulphur sprays, leaves no doubt that the mixture was very much safer on apple foliage than the lime-sulphur sprays."

In a few cases a certain amount of "yellow leaf" has followed the last summer application of the lime-sulphur aluminium mixture with calcium arsenate on varieties which are susceptible to this trouble. This "yellow leaf" is associated with the arsenate of lime used and the cause is not entirely understood. Unless insect conditions warrant otherwise it would seem advisable to reduce the arsenate of lime to ½lb. per 40 gallons of spray mixture for this application.

Experiments in Nova Scotia have demonstrated repeatedly that the calcium arsenate in this mixture definitely increases the fungicidal value of the spray, and that without the calcium arsenate the mixture is definitely poorer in fungicidal value than the standard spray materials. Therefore calcium arsenate should be added, even though its presence as an insecticide may not be required.

Certain objections have arisen in connection with the use of the mixture. Due to the hydrogen sulphide given off, the odour of the spray is very obnoxious. It has been found that there is danger of breathing this gas in concentrated form so that care must be exercised in opening the spray tank. There is also some danger that the gas may be inflammable under some conditions so that it is inadvisable to have a naked flame in the tank before it has been sufficiently ventilated.

Another objection to the use of the mixture is that the hydrogen sulphide gas corrodes the metal parts of the spray valves of certain machines and makes them shorter lived than they would otherwise be. The corrosion would be considerably lessened if the orchardist were to wash out the tank with water after each day's spraying. If this mixture comes into greater use the manufacturers will doubtless develop new metal alloys for the affected parts.

In commercial practice in Nova Scotia the materials are used at the rate of one gallon of lime-sulphur 33° Baume, 3½ lbs aluminium sulphate crystals and one lb. calcium arsenate to 40 gallons of water. The aluminium sulphate is added when commencing to fill the spray tank. When the tank is nearly full the lime-sulphur is added while the calcium arsenate and nicotine sulphate if used are added last.

The reaction as outlined by Kelsall (4) is as follows:

$$3CaS_5 + Al_2(SO_4)_3 + 6H_2O = 3CaSO_4 + 2Al(OH)_3 + 3H_2S + 12S$$

Lime-sulphur Iron Sulphate Mixture.

In 1910 Waite reporting on limited experiments in Virginia stated that iron sulphate with self-boiled lime sulphur was a very promising spray mixture.

He found practically no foliage injury from lime-sulphur when iron sulphate was added. His results have been substantiated by findings in Nova Scotia using the commercial liquid lime sulphur. When this mixture is applied it is of an inky black colour, in a few days oxidizing to a rusty brown. Later in the season the foliage on these plots is remarkably green and vigorous.

From limited data the fungicidal value of this spray is comparable to that of lime-sulphur aluminium sulphate mixture, calcium arsenate being used with both mixtures and 4lbs. of iron sulphate to 40 gallons of water. However, due to the poor appearance of the trees immediately after application it is doubtful if this spray gains great popularity.

Dutton (2) reports on the use of iron sulphate with lime-sulphur and lead arsenate in Michigan. From experiments in three seasons he recommends the addition of ½lb. of iron sulphate to the lime sulphur arsenical spray.

If the reactions proceed as indicated for the lime sulphur aluminium sulphate mixture the following would take place:

$$CaS_5 + FeSO_4 + 7H_2O = CaSO_4 + Fe(OH)_2 + 2H_2S + 3S$$

It would appear that ½lb. of iron sulphate would be insufficient to complete the above reaction; and it has been suggested tentatively therefore that the protective action secured in Michigan may be due to a reaction in some manner with the lead arsenate $PbHAsO_4$.

Self-boiled Lime-sulphur.

While this is largely a mechanical mixture the heat generated by the slaking lime leads to the formation of some mildly caustic calcium and sulphur compounds.

It is lower in fungicidal value than is the ordinary liquid lime-sulphur.

Dry Lime-sulphur.

This spray mixture is simply the liquid form of lime sulphur which has been reduced to the dry state by the evaporation of the water, and to which some kind of stabilizer is usually added. Its insecticidal and fungicidal constituents are largely if not entirely the same as in liquid lime-sulphur.

In commercial practice it has been found that approximately four pounds of this material will give equal results to one gallon of the liquid concentrate 33° Baume. The cost has been reported by different workers to be from one-fifth more to more than double the cost of the liquid spray. Munn (5) reports that dry lime-sulphur washes off the foliage rather easily. It has been claimed

that this material is less liable to cause spray injury than is liquid lime-sulphur. This spray mixture, while used commercially in several other orchard districts has not gained much prominence in Nova Scotia.

Dry Mix Lime-sulphur.

This is a mechanical mixture of lime-sulphur and a spreader. It is usually used in the concentration of 8 lbs. sulphur, 8 lbs. hydrated lime, ½lb. calcium caseinate or an equivalent spreader in 40 gallons of water. It is more costly than liquid lime-sulphur and has been reported as giving poorer control of scab but less foliage and fruit injury used as a summer spray.

Wettable Sulphur.

While sulphur alone is a powerful fungicide, it is impossible to obtain an intimate mixture of the sulphur with water, the powder remaining on the surface even after the most vigorous stirring. Vermoral and Dantony in 1910 recommended the use of 1% soap solution and 1% sodium carbonate as a medium to increase the miscibility of the sulphur in water. However as soap cannot be used in combination with acid lead arsenate or calcium arsenate, other substances have been substituted for soap. Calcium caseinate, oleic acid, glue, gelatin, diatomaceous earth, dextrin and flour are used as fluxes.

The commercial wettable sulphur now on the market is usually applied at the rate of 30 lbs. per 100 gallons of water and is considered to be a safe fungicide with respect to the fruit and foliage of the apple but is much lower in fungicidal value that the lime-sulphur mixture. It is often used when special insect conditions require the excessive drenching of trees with poisons in the fungicidal sprays. In Ohio it has been reported as causing slight burning of the edges of the leaves.

Soluble Sulphur.

This is a compound of sodium and sulphur or of potassium and sulphur. In Ohio it has been found equal to lime-sulphur as a dormant spray when used at the rate of 12½ lbs. to 40 gallons of water. It has been used to a slight extent in Nova Scotia but has not gained popularity.

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SOME ADVANTAGES OF NICOTINE DUSTING

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The method of applying insecticides and fungicides in the dry form as an alternative to the liquid method is a practice that is by no means a new one. Indeed sulphur dusting on a large scale to control downy mildew of grape has been practiced in France for well over half a century. However, the discovery of such liquid fungicides as Bordeaux mixture and later lime-sulphur and the coincident development of efficient spraying apparatus held back for many years any important advance in the use of the dusting method. On this continent, though, the utilization of dusts, particularly for insecticidal purposes persisted to some extent. The introduction of improved dusting machinery together with the results obtained by Blodgett (1) and by Reddick and Crossby (2) by the use of "superfine" dusting sulphur for orchard dusting gave an impetus to experimenters in this field. The introduction of so-called Bordeaux or copper-lime dusts through the work of Sanders (3&4) and his co-workers, and of nicotine dusts growing out of the experiments of Smith (5) in California, resulted in greatly increasing the acreage treated by this method.

The most enthusiastic advocates of dusting claimed that dry materials could be used for everything for which liquid materials were employed with equally good effect, together with all the added advantages in time-saving, ease of application, less expense, more easily operated and lighter machinery, and comparative freedom from spray injury characteristic of this method. With more experience we are now able to obtain a better perspective of the virtues of the two systems, and to recognize that, while dusting has won for itself a definite and important place in cotton dusting for boll weevil, and in general crop dusting under some conditions, it is now recognized that, at least as far as orchard dusting is concerned there are some things that cannot yet be done by dust. The fact that no satisfactory dust has been devised for scale insects or for the European red mite, that for the control of bud-moth epidemics dusting appears to be inadequate, and that for severe cases of apple scab the dusting method is less satisfactory or more expensive than the liquid treatments, make it impossible to rely on dusting alone in many orchard districts. The fact that dust applications are often possible when spraying is difficult or impossible, as on heavy wet lands or during periods of frequent rains, and the ease and speed with which applications can be made, are some of the reasons that have caused many orchardists to retain the duster in use even when depending on the sprayer for the bulk of their work. Others, while using liquid treatments for the pre-blossom applications in the apple orchard to keep down primary scab infection at a time when rapid spraying can be done owing to the only partially developed

foliage, change to dusting for all post-blossom applications when the foliage is denser, requiring more material, slower work, and involving greater danger of spray injury.

There is still another condition that places the owner of a duster in a position of advantage in his warfare with the various pests that attack his orchard. Such a condition exists when he has to contend with some of the larger sucking insects such as various species of Miridæ. Common examples of these are the green apple bug (*Lygus communis* Knight) and the apple red bug (*Lygidea mendax* Reut.). The speaker's experience is mainly with the first of these, which incidentally, appears to be the most destructive and at the same time the most resistant of the apple infesting species. Fortunately, our Quebec orchards seem to be singularly free from insects of this type, but it seems too much to expect that with the development of the apple industry, this happy condition of affairs is likely to continue.

It has been the experience of the speaker, over a period of several years, that the results obtained by spraying for insects of the type of the apple green bug—that is, the results obtained by the average grower—have been, on the whole, decidedly disappointing. This is readily accounted for when we consider the size and activity of these insects and their almost uncanny ability to conceal themselves between the flower stalks or to wedge themselves in between the blossom petals or to find similar places of concealment. The heavy drenching sprays required to secure control when the liquid method is used render the work so slow and laborious that, when the operation is undertaken at the proper stage in the development of the blossom, the latter are likely to be wide open before the work is completed. When it is remembered that a delay of five days in the application of the material has meant as great a loss as a barrel a tree in cases of such severe infestations as often exist in Nova Scotia orchards, the seriousness of this factor is at once apparent. Added to this is the further fact that the heavy sprays necessary to secure control are likely to result in heavy loss from spray injury when the nicotine sulphate is combined with fungicide sprays. On the other hand when the dusting method is used, the material can usually be applied at the optimum time without danger of injury and the standard nicotine dusts usual in orchard practice (containing 2 per cent of actual nicotine or 5 per cent commercial nicotine sulphate) when applied under favorable conditions and in adequate quantity have proven remarkably effective in controlling the species referred to. Ideal conditions for application have proven to be still air, dry foliage, and a comparatively high temperature. Dusting during the day is rarely possible in Nova Scotia owing to the fact that it is difficult to secure the first of these conditions at any time during the day. The early morning is rarely as good a time as the evening, since the temperature is usually lower and the leaves apt to be damper. Any period when the air is absolutely calm, unless the leaves are actually wet, should be utilized, once the blossoms are in the proper stage for treatment to be given.

It has been our experience that correct atmospheric conditions are more important than slight changes in the chemical constitution of the carrier. Aside from absorbent carriers such as kaolin or inert carriers such as sulphur which were inferior, it was found under orchard conditions that the standard 2 percent nicotine dust (5 per cent commercial nicotine sulphate) used in Nova Scotia with hydrated lime as a carrier gave excellent commercial control of the pest. Slight differences between this material and others using dolomite and other types of lime as carriers could usually be accounted for on other grounds than chemical constitution. A slight breeze springing up at the time of the application of any dust invariably gave a lower percentage kill. A drop in temperature similarly reduced the percentage control. A rise in temperature increased the effectiveness of the treatment. It was early noticed that with a lower temperature it was necessary to use heavier applications of material to produce the same result as when higher temperatures prevailed.

Since all the dusts contained an excess of nicotine sulphate over what would be required under optimum conditions to secure control, it is possible that the formulæ on the border line of toxicity would have been more satisfactory for experimental purposes. Nevertheless it was clearly established that the commercial preparations used by the growers were quite satisfactory, giving better results in the hands of the average grower than he would be likely to obtain if he had depended upon the spraying method.

Recent work carried on by Kelsall has shown that the eye-spotted budmoth (*Tmetocera ocellana*) may be controlled in the adult stage by the application of nicotine dust, but since we here have an equally effective and cheaper alternative in the spraying method this will not be considered at this point. There has been recently carried out interesting and important work in nocotine dusting for flea beetles. I shall, however, content myself with a final example from one of our common field crop pests, viz. the potato aphis (*Illinoia solanifolii* Fitch). This insect also has not been controlled with entire satisfaction by means of sprays. Not only is this species very resistant to the action of sprays, but it early causes a severe curling of the leaves which adds to the inherent difficulty of using contact sprays on low-growing crops. Tests with standard nicotine—hydrated lime dusts carried out by the speaker in 1924, indicated that practically 100 per cent control could be secured with dusts of 1.6 per cent nicotine strength (4 per cent nicotine sulphate), when used in conjunction with a canvas "trailer". The use of the trailer together with a good dust cloud, adequate pressure and sufficient material is essential to these results, though there is some question as to whether the dragging of the canvas over the plants does not serve to spread virus diseases such as mosaic. As far as the control of aphids and other sucking insects on low-growing crops such as potatoes, turnips, etc. is concerned, the use of nicotine dusts applied by means of a crop duster used in conjunction with a trailer or canopy would appear to have many marked advantages.

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SULPHUR AS A DETERRENT TO JUNE BEETLE (Phyllophaga anxia Lec.) OVIPOSITION IN TIMOTHY SOD

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The Hemmingford district has been heavily infested by white grubs for a number of years and, in common with other grub-infested areas in the province, the aggregate losses have been heavy. In analyzing the situation in various districts it was apparent that crop rotations and other recognized white grub control measures were being overlooked. The heaviest grub infestation in the Hemmingford district found last year was in timothy sod which had not been plowed for over 12 years. However, conditions are met with upon occasion where white grub infestation under the circumstances cannot be materially reduced with ordinary cultural methods. Fields which were in sod when a June beetle flight was in progress for instance may contain a sufficient number of grubs to seriously injure susceptible crops the following year. Therefore, in the case of lawns, golf links, orchards, pastures and other areas which may not be conveniently plowed previous to a major June beetle fllight an efficient preventive or deterrent of oviposition by the beetles is desirable where the expense of treatment is not prohibitive.

Field experiments were conducted during 1928 to determine the value of sulphur dust for this purpose. It was dusted over measured plots in various quantities on May 18 just previous to the first heavy June beetle flight. When the flight of beetles had subsided, the check and dusted plots were examined for June beetle eggs and white grubs in the first instar. In making the examination the soil with the sod convering was carefully dug out to a depth of 10 inches with a shovel and placed on a sorting table for study. Most of the eggs were discovered to have hatched and young grubs were encountered more commonly than eggs. Injury to the grass from the sulphur was noted to be slight and it did not affect five per cent of the total where the heaviest applications of sulphur were used. Further, this injury was temporary and was mainly due to uneven distribution of dust.

The following is a summary of the averaged results of two series of experiments conducted in the same field at a distance of 100 feet apart.

Tabulation indicating the number of white grubs and eggs, the percentage of protection, the amounts of sulphur used and the costs involved upon a one year and three year basis in the several experiments.

Section of experiment	Total White Grubs & Eggs	Per Cent Protection	Quantity of Sulphur Per acre (lbs.)	Cost Per Acre 1-yr. Basis	Cost Per acre 3-yr. Basis
1	89	(check)	.....	.....	.....
2	13	85.4	567	$14.17	$ 4.72
3	16	82.1	850.5	21.26	7.08
4	13	85.4	1219.	30.47	10.15
5	9	89.9	1474.2	46.06	15.35
6	2	97.8	.....	.....	.....

N. B.—Cost estimated on sulphur at $2.50 per 100 lbs.

From the foregoing table it may be seen that sulphur gives promise of becoming an important deterrent of June beetle oviposition in the case of grass areas. A degree of protection of over 80 per cent was secured in each case and up to nearly 100 per cent with increased amounts of material. It is apparent, however, that the degree of control or protection obtained with approximately trebled quantities of sulphur applied was far out of proportion to the quantity of material applied and it is possible that further experimentation will show that commercial control of, or protection from grubs, may be obtained from even smaller quantities of material per acre.

The application of the sulphur was simple, involving a minimum of labor with moderate cost when compared with the cost of application of carbon bisulphide and other liquid soil fumigants or insecticides.

While these preliminary experiments are not extensive enough to form a basis for final conclusions, the fact that sulphur has a distinct value in preventing significant June beetle oviposition in sod is strongly indicated. The cost of treatment is sufficiently low to allow of the use of sulphur under many conditions of intensive culture and even under some conditions of extensive culture.

EFFECTS of SOME SULPHUR SPRAYS on FRUIT-BUD DEVELOPMENT

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In 1928, Koloform, one of the newer sulphur sprays, was compared to lime sulphur on apple. Koloform is prepared by fusing bentonite and sulphur with the addition of calcium caseinate to aid in mixing it with water. Lime sulphur was used at the rate of 1 gallon to 40 gallons of water and the koloform 8 lbs. to 40 gallons water. The sprays were applied six times under similar conditions. It was noticeable throughout the season that foliage injury was quite prevalent in the lime-sulphur sprayed trees, whereas those sprayed with koloform were not injured. The lime-sulphur injury consisted in burning and dwarfing the foliage. Late in the season a difference in the size of the buds on the two plots was very noticeable. The buds on several of the branches were measured and these measurements are recorded in the following table.

	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{9}{16}$	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{7}{8}$
Koloform	3	3	23	24	75	19	18	1	1
Lime sulphur . . .	7	17	40	23	29	2	2	0	0

A study of these figures shows 17.4 per cent of the koloform buds were less than $\frac{7}{16}$ inches and 53.3 per cent of the lime sulphur buds were in this class. In the koloform plots 68.4 per cent of the buds, and 27.5 per cent of the buds in the lime sulphur plots were over $\frac{7}{16}$ inches in length. The average length of the buds sprayed with koloform was .4903 inches, whereas the length of those sprayed with lime sulphur was .3979 inches. The increase in length from the apparent use of koloform was .0924 inches or 23.22 per cent. It is my opinion the extra size was obtained from the greater size of the foliage which resulted from its not being burnt or dwarfed.

SOME STUDIES ON THE USE AND ACTION OF BICHLORIDE OF MERCURY AS A FUNGICIDE

By J. L. Howatt, Macdonald College.

The compounds of mercury have occupied a prominent place in the field of medical therapy for many years and have been of the greatest service to man in combatting and controlling certain human diseases. A new field of usefulness was opened to mercury compounds, when Bolley, in 1890, demonstrated and recommended the use of mercuric chloride for the control of potato scab caused by *Actinomyces scabies*. Following Bolley's work the bichloride was about the only mercuric compound employed by phytopathologists until 1912, when many new preparations known as organic mercury compounds were introduced. It is claimed that the organic mercury compounds have a larger field of usefulness, as fungicides than the bichloride of mercury. They apparently do not deteriorate nor loose their fungicidal value with constant usage, and are said to be efficient to the last drop.

Mercuric chloride is a white crystalline powder soluble to the extent of 5.73 grammes in 100 grammes of cold water; 53.96 grammes in 100 grammes of boiling water; and 43.5 grammes in 100 grammes of cold ethyl alcohol.

Bichloride of mercury is a violent poison, producing considerable inflammation in, and eventually destroying mucous membranes.

The solution of mercuric chloride is facilitated by the presence of hydrochloric acid or ammonium chloride. Solutions of the salt precipitate albumens with which it forms a mercuric salt soluble in excess of albumen. The toxic action is therefore due to the property of precipitating albumens and other ingredients of the protoplasm.

The toxic action of mercuric chloride varies with the amount of dissociation and the concentration of metallic ions in the solution. (1) LaPlace has pointed out that the addition of a small amount of an acid to a solution of mercuric chloride greatly increases its efficiency, and by lessening the formation of insoluble albuminates thereby increases the power of penetration. Kronig and Paul have denied this and assert that the addition of sodium chloride to mercuric chloride diminishes its toxic acid. They claim the same effect for potassium chloride and hydrochloric acid.

MODE OF ACTION

But little study has been made on the effect of mercuric chloride in or on the cell. It is known that the solution is soluble in lipoids, a substance claimed by Overton, Raber and others as the major component of the cellular mem-

brane. There appears to be two ways to account for the toxicity of the salt. In the one case it is considered that solutions of the salt precipitate the extracellular membrane with consequent adsorption on the surface, thus preventing germination. In the second mode of action it is considered that the salt penetrates the membrane and undergoes periodical precipitation and solution, eventually causing in excess, the precipitation of the entire protoplasm.

In connection with the first theory the work of Klein, (2) with *Bacillus anthracis* is interesting. He treated anthrax spores with a solution of mercuric chloride made up to the strength of one part of mercuric chloride to one thousand parts of water, and he noted that the bacteria were apparently killed and the spores ceased to develop; but on inoculating guinea pigs with the apparently sterilized anthrax infusion, anthrax rapidly developed and the animals died. Klein concluded that the mercuric chloride only stupefied the spores of the bacillus. Dr. Woodhead explained Klein's results as due to the precipitation of the mercuric choloride by the albumen present, which coated the spores with mercuric albuminate, which when introduced into the blood stream of the guinea pigs, redissolved in the excess of the albumen, setting free the organisms to flourish.

Engelhardt, (3) has shown that the salt is adsorbed upon the surface of bacteria, thus preventing germination, and that by removing the absorbed mercuric chloride by treatment with animal charcoal or hydrogen sulphide and subsequent washing, the bacterial spores were able ro resume their functions.

It seems reasonable to consider that the control effected in certain seed borne diseases by seed treatment with mercuric chloride is due to the retardation of the germination of the spores, to such an extent that they are outgrown by the host, and are thus removed from the meristematic tissue which is necessary for their further development. This may be instanced in certain smut diseases.

TOXICITY.

The toxicity of mercuric chloride depends upon its concentration, temperature, time of action, association, age of spore and host plants, and type of seed. In very dilute solutions the fungicide may act as a stimulant as has been reported by Schultz for *Saccharomyces cervesiaa,* which was considerably activated in a solution made up to the strength of one part of mercuric chloride in five hundred thousand parts of water. It is well to keep in mind however, that many of the so-called stimuli recorded in the growth of plants after soil treatment with mercuric chloride is not due to the direct action of the fungicide

on the plants, but rather to the indirect partial sterilization effect on the soil, with the consequent availability of more plant food due to the lack of competition with soil microorganisms.

Excessively strong solution of mercuric chloride may not penetrate because of their rapid precipitating action. In these cases there may be adsorption at the surface.

The temperature of the solution highly modifies the time of exposure, as is instanced in the time of exposure to hot or cold solutions. The time of action is also of importance, too short an exposure reducing the efficiency, too long an exposure increasing the danger of toxicity to the host.

The association factor is of the greatest importance especially if large amounts of solution are to be used for any extended period of time. Reduction in strength takes place very rapidly, a point to be considered in seed treatment.

Hurst and Howatt (4) have studied the factors leading to the deterioration of mercuric chloride solutions employed in potato seed treatment on Prince Edward Island. These investigators found that seed treatment methods as ordinarily employed on Prince Edward Island were open to serious objections. Their investigations extending over a period of three years have led to the following conclusions:

1. Solutions of bichloride of mercury used in potato seed treatment with special reference to rhizoctonia, should be discarded when the strength of the recommended standard solution (mercuric chloride one part to one thousand parts of water) has been reduced to one part in twelve hundred and fifty parts of water.
2. Moistening the potatoes before immersion in the mercuric chloride solution is an aid in seed treatment as it renders the sclerotia more easily penetrable by the fungicide.
3. Mercuric chloride solutions are rapidly reduced in fungicidal efficiency by association with burlap bags and adhering soil particles. The chemical composition of the water used in preparing the solution and the number of cracked and damaged tubers are also important factors.
4. Any one solution should not be used for more than four treatments.
5. Changing the solution into a clean cask and removing all the dirt and sediment from the one previously used will prevent much deterioration.
6. Mercuric chloride must be thoroughly dissolved lest the crystals settle out to the bottom of the cask and remain undissolved.
7. An addition should be made to the solution after each treatment to maintain the strength of the fungicide up to the accepted standard.

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PROTECTION OF TREES FROM INSECTS

By E. P. Felt, D.Sc., Director and Chief Entomologist. Bartlett Tree Research Laboratories, Stamford, Ct.

This subject is a broad one and the discussion will be limited largely to insects affecting shade trees.

It is not generally known that Asa Fitch was the first official Entomologist in America, born in 1809 and active entomologically from 1854 to 1879 and the first Entomologist to make a serious study of shade tree and forest insects. He laid a biological foundation which has been of immense service to his successors. It is interesting to recall the fact that arsenical poisons for the control of insects were not known at that time.

The successor of Fitch, Joseph Albert Lintner, born in 1822, was officially active from 1874 to 1898, first as zoological assistant in the State Museum and from 1880 until his death in 1898 he was State Entomologist. Even in his time, the spraying of shade trees was considered too costly, and in the case of the elm leaf beetle, Dr. Lintner contented himself with recommending such repressive measures as destruction of the larvæ and pupæ as they swarmed upon the trunks and at the base of infested trees.

John Henry Comstock, illustrious teacher and beloved of all his students, was active in scientific matters from 1872 to 1914, a period of 41 years. His was a phenomenal career, an orphan, starting as a sailor on the Great Lakes and later the head of the most influential entomological department in the world. He it was who established a scientific basis for the study of the comparatively unknown scale insects, an enormous group comprising some 1500 species as listed in the Fernald catalogue.

Mark Vernon Slingerland was born in 1864 and active in Entomology from 1890 to 1909. He was a keen enthusiastic instructor and left noteworthy examples of biological studies. He passed before the discovery of calcium cyanide as an insecticide.

Before going on, here is a little of the human side of Entomology. It may appear as though there were larger opportunities in the earlier days, but we are unwilling to admit this and believe that the future holds much for the careful student of insect life. There is perhaps no more attractive field than that offered by the insects of shade trees, including ornamentals and those of the forests.

[The speaker exhibited a long series of lantern slides making brief comments upon each.]

The insectary of the Bartlett Tree Research Laboratories is unique among insect structures in that it is devoted to the study of shade tree and forest insects. [Views were shown of both the exterior and the interior. There was also a slide representing the insectocutor, a patented device for the electrocuting of insects which may be attracted either by a light or baits. They are destroyed as they attempt to pass between highly charged wires. The device has proved very successful in killing house flies about dwellings and dairy barns and may have an application in reducing the numbers of certain shade tree and forest insects.]

The apple tent caterpillar, *Malacosoma americana*, is easily recognized on account of the conspicuous white tents in the forks of the limbs of wild cherry and apple in particular. It is a very common insect, frequently quite destructive and readily controlled by timely applications of a poison. The related forest tent caterpillar, *Malacosoma disstria*, occasionally occurs in epidemic numbers, defoliating large areas. It is interesting to know that on Long Island, it is an enemy of oaks, that it is destructive to sugar maples and apple trees in the Catskills and adjacent sections of the Hudson River Valley, while in the Adirondacks, it is a depredator upon poplars. The white marked tussock moth, *Hemerocampa leucostigma*, is one of the common shade tree pests of the Northeastern United States. It displays a marked partiality for horse chestnut and linden and feeds commonly upon elm and maple. A related species, the rusty tussock moth, *Notolophus antiqua*, is somewhat more Northern and is more likely to occur in Canadian areas. The habits of the two are very similar. The bagworm, *Thyridopteryx ephemeraeformis*, is a Southern general leaf feeder, noteworthy in particular on account of its depredating upon various evergreens, especially arbor-vitæ. The spiny elm caterpillar, *Euvanessa antiopa* is one of the common elm insects. The black spiny caterpillars feed in clusters and habitually defoliate one or more of the smaller terminal branches. The elm leaf beetle, *Galerucella luteola*, is an introduced insect now generally distributed in the Northeastern United States and becoming established farther west. It was exceedingly destructive to city trees in the 90's and now is satisfactorily controlled by spraying, a process earlier considered too expensive for shade tree work. The hickory tussock caterpillar, *Halisidota caryæ*, is a rather general forest leaf feeder, occasionally somewhat destructive.

The European larch is subject to attack by several insects. The larch sawfly, *Nematus erichsonii*, is rapidly defoliating extensive areas of larch in the Adirondacks and Canadian forests, and is a serious enemy of trees put out as ornamentals. The larch is also subject to attack by the case bearer, *Coleophora*

laricis, a European insect occasionally extremely abundant and producing a generally browned condition of the developing leaves. The larch woolly aphis *Chermes strobilobius*, occasionally becomes very abundant and in early summer, infested trees appear as though they were lightly dusted with flour or very small particles of woolly matter. The hickory horned devil, *Citheronia regalis*, is one of our largest caterpillars, attaining a length of 4 to 5 inches. It is a Southern insect rarely numerous enough to cause any material injury. It is simply one of the interesting forms occurring upon various trees and the same is true of the saddleback caterpillar, *Sibine stimulea*, a slug caterpillar which feeds upon a variety of trees, is rarely abundant enough to cause material injury and invariably attracts notice on account of its peculiar shape and unusual coloration.

The willow leaf beetle, *Plagiodera versicolora*, is a somewhat recently introduced insect now well established in the Northeastern United States and causing serious injury to willows. The beetles appear in early spring. There are several generations, and consequently more or less continuous injury. The Japanese beetle, *Popillia japonica*, is another recently introduced species destined to become widely distributed, though it is hardly likely that it will become injurious in Canada. The beetles feed upon a large variety of trees and other plants, displaying a marked preference for linden, horsechestnut, rose, willow, sweet cherry and a number of other trees. The usual orchard spraying schedules prevent injury under commercial conditions. It is a somewhat serious problem to control this insect on a few favored food plants upon estates or smaller private holdings. The Asiatic beetle, *Anomala orientalis* and the introduced, so called twilight garden beetle or Japanese serica, *Aserica castanea* are well established in the New York area and adjacent territory and while they, like the Japanese beetles, are destined to expand their distribution, they are not as injurious, though the grubs are serious enemies of sod in particular.

The satin moth, *Stilpnotia salicis* is another European insect well established in New England and recorded from Western Canada. It is an enemy of poplar and willows and may be of considerable importance in connection with pulp wood production. The recently introduced birch leaf miner, *Fenusa humilis*, is a small sawfly first observed in this country in 1923 and now widely distributed throughout Southern New England, Southeastern New York, Northern New Jersey and Northeastern Pennsylvania, at least. It has spread with remarkable rapidity, the small sawflies with a wing spread of only about one-fourth of an inch, evidently drifting long distances with the wind. The native birch leaf skeletonizer, *Bucculatrix canadensisella* is a native species, occasionally occurring in such large numbers as to skeletonize most of the leaves over considerable areas. It is not a particularly important insect.

The sugar maple borer, *Glycobius speciosus* is a rather common and decidedly pernicious borer, although adults and grubs are rarely seen. There are very few perfect maple trees in the Northeastern United States and a very considerable proportion of these have been seriously injured or damaged by this native insect, a pest which I believe is susceptible to control. The work of the sugar maple borer produces conditions favorable for the development of the pigeon tremex, *Tremex columba*, a species which in our experience, develops only in fungus infected wood, and the lunate long sting, *Megarhyssa lunata*, a parasite of both the sugar maple borer and the pigeon tremex and therefore beneficial, although the insect's habit of driving its long ovipositor some four inches into the tree very commonly arouses apprehension as to its relation to tree welfare. It is simply endeavoring to place eggs where the hatching young may find one or the other of the borers just mentioned. The leopard moth, *Zeuzera pyrina*, is an introduced pest now well established and very destructive to many trees along the North Atlantic Seaboard, it being especially prevalent in soft maples. It is primarily an urban insect and its work is easily recognized by the characteristic breaking of limbs one to two inches in diameter and the irregular borings in larger branches and even the trunks of trees. The carpenter worm, *Prionoxystus robiniæ*, is a native borer, occasionally abundant in oak and ash in particular. It produces ugly wounds in the larger limbs and branches. The caterpillars bore in the wood and are not nearly so injurious to the trees as the cambium working grub of the sugar maple borer. The locust borer, *Cyllene robiniæ*, is a common enemy of the black locust and in Southeastern New York State it is exceptional to find trees or groups of trees which have not been rather generally affected by the work of the grubs of this brilliantly colored beetle. The elm borer, *Saperda tridentata*, is rather common in elm trees. The grubs work in the cambium and sapwood. Attack by this insect frequently precedes invasion by two small weevils, *Magdalus armicollis* and *M. barbita* These latter make more slender galleries than those of the larger elm borer. The hickory bark beetle, *Scolytus quadrispinosus*, is a native bark beetle which has destroyed thousands of magnificent hickories and is particularly likely to be abundant after several seasons of unusually dry weather have lowered the vitality of the trees, and made them more susceptible to attack by this borer. The twig girdler, *Oncideres cingulatus*, is a rather common enemy of hickories. Its work is easily recognized by the characteristic broad girdlings of smaller branches accompanied by a slight scarifying of adjacent bark. The maple and oak pruner, *Hypermallus villosus*, has somewhat similar habits to the preceding and is most likely to be common in the smaller branches of maple and oak. These are cut off smoothly as though with a knife and the grubs winter in the fallen limbs. Systematic picking up and burning of these during the winter or early spring is an effective check upon both of these twig girdlers.

The pine sawyer, *Monochamus titillator*, occurs rather commonly in sickly and dead pines, working first in the sapwood and eventually boring through the trunk and producing characteristic piles of coarse sawdust. It is very injurious to exposed logs left in the woods during the warm months. The white pine weevil, *Pissodes strobi* is very common and its work is easily recognized by the browned or dead leaders in mid-summer. Bushy pines are suggestive of a general infestation by this insect. There is no satisfactory method of controlling this pest on ornamentals, though its injuries may be minimized in various plantings by thick setting and to some extent by cutting out and burning infested shoots.

The grape tomato gall is produced by a small midge, *Lasioptera vitis* and the gouty, usually bright colored deformity, frequently attracts notice, although it is not particularly injurious to the vine. The oak pill gall is produced by another gall midge, *Cincticornia pilulæ* and though common it is rarely sufficiently abundant to be injurious though one such case has been brought to our attention. The large oak apple is caused by a gall wasp, *Amphibolips confluens* although the galls are ordinarily not sufficiently abundant to seriously affect the tree. Occasionally the galls are extremely abundant and we have seen a few cases where the infestation suggested a tree well loaded with apples. There are a large series of both gall wasps and gall midges, most of them being of comparatively little importance.

The arbor-vitæ leaf miner, *Argyresthia thuiella* is rather common in Southeastern New York and Southwestern New England, frequently producing a somewhat generally browned unsightly condition of the leaf tips. Thorough spraying with a tobacco soap preparation early in July has given excellent results. The large European hornet, *Vespa crabro*, is rather generally established in Southeastern New York State, at least, and is occasionally injurious to shrubs on account of the wasps stripping off the bark in order to obtain nesting material. The work is sometimes suggestive of the operations of a small child with a toy saw.

There are a number of species of plant lice which seriously affect various shade trees. The Norway maple aphid, *Chaitophorus lyropicta*, is very common and in exceptional seasons may be so abundant as to cause the dropping in mid-summer of a large proportion of the foliage. It produces copious honeydew which may keep stones and walks under the trees wet in even drying weather. The alder blight aphid, *Prociphilus tessellatus*, literally festoons alder branches in the Adirondacks and is sometimes extremely abundant upon the leaves of soft maple. The connection between these two forms is a comparatively recent demonstration. The rhododendron lace bug, *Stephanitis rhododendri* is very common and its presence is easily recognized by the unsightly yellowish or

brown spotting of the foliage. Spraying the under surface of the leaves with a contact insecticide early in June is a most effective control measure.

The scale insects attack a very considerable variety of trees and shrubs. The San Jose scale, *Aspidiotus perniciosus*, is a well known enemy of many trees and shrubs and thrives particularly upon the Japanese quince as well as a number of fruit trees. The elm scale, *Gossyparia spuria* is responsible for many of the weakened smaller limbs of elm and the same is also true of the more common and better known oyster shell scale, *Lepidosaphes ulmi*. The golden oak scale, *Asterolecanium variolosum*, is becoming well established upon oaks in different sections. It has proved very destructive in some localities. The cottony maple scale, *Pulvinarisa vitis*, is a widely distributed species occurring upon a large variety of plants and particularly injurious to soft maples. The twigs of this last are frequently festooned with white cottony matter and the foliage well smeared with usually blackened honeydew. The tulip tree scale, *Toumeyella liriodendri*, is a common scale upon the tulip tree. It secretes large amounts of honeydew in mid-summer and produces very unsightly conditions, as well as causing the death of smaller limbs.

Figs. 1-9 from Felt's "Manual of Tree and Shrub Insects," are published by courtesy of The Macmillan Company, of New York. figs. 10-12 by courtesy of the Bartlett Tree Research Laboratories.

NOTES ON THE DISTRIBUTION OF THE CYCLAMEN MITE Tarsonemus pallidus Banks

By Alan G. Dustan, Entomological Branch, Ottawa, Ontario

For the last two or three years it has been noticed that scattered plants in some of the strawberry beds at the Central Experimental Farm, Ottawa, have not been developing as they should. The plants appeared stunted and unthrifty and the leaves were very much curled, wrinkled and distorted. Furthermore, such plants produced very few, or no, runners and bore practically no fruit. A study of this peculiar condition was made by Mr. R. H. Painter of the Entomological Branch who noticed that a small, pale mite was always associated with the plants showing this peculiar type of injury while healthy plants in the same bed were uninfested. Specimens were forwarded to Mr. George Darrow, United States Department of Agriculture, Washington, for identification by Mr. M. B. Davis of the Central Experimental Farm, who reported them to be the cyclamen mite, *Tarsonemus pallidus* Banks.

Fig. 1.—White-marked tussock moth, caterpillar, male, female, egg mass and cocoons, reduced.

Fig. 2.—Forest tent-caterpillar, adult, cocoon, larva, old larval skins and egg mass, reduced.

Fig. 3.—Spiny elm caterpillar, eggs, full-grown larva and work, reduced.

Fig. 4.—Imported willow leaf-beetle, beetle, grubs and their work, pupa enlarged.

Fig. 5.—Elm borer, grub and galleries, pupa, adult (enlarged); smaller borings work of elm snout-beetles, reduced.

Fig. 6.—Hickory bark-beetle, exit holes and galleries, much reduced.

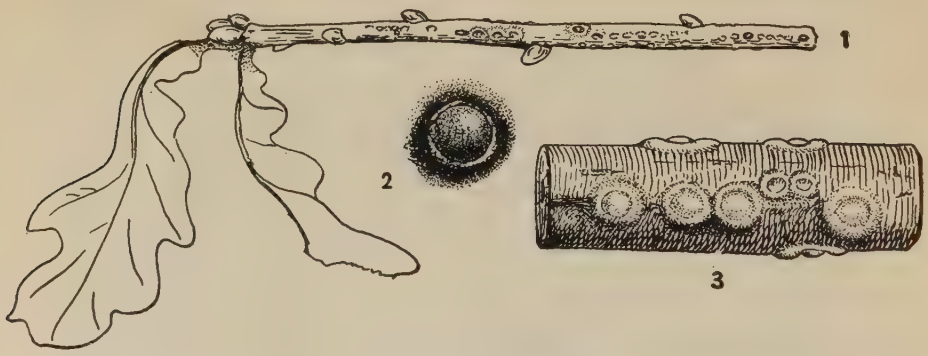
Fig. 7.—Maple and oak twig-pruner, work on small branches, borer and pupa, in galleries, reduced.

Fig. 8.—Sugar maple borer, showing egg-slit, young and full-grown borers, beetle, exit hole and work, reduced.

Fig. 9.—Tulip tree scale, badly infested twig.

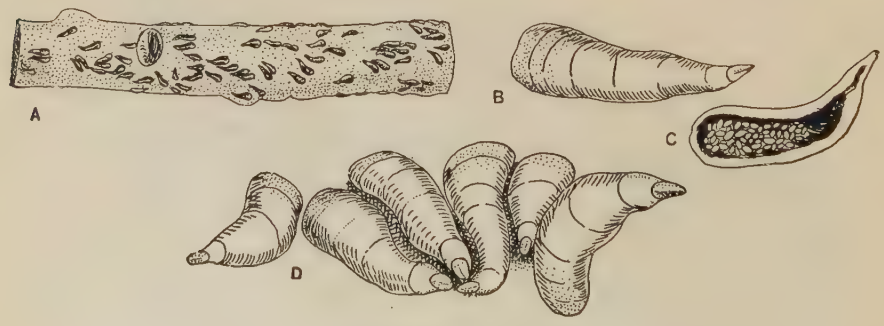
SAN JOSE SCALE

Fig. 10.—1. Branch enlarged with the circular female scales surrounded by smaller young ones and several oblong male scales. 2. A group of partly grown and full grown scales with numerous young nearby and the minute yellowish crawling young on a black background. 3. A portion of rather badly infested bark showing the scales overlapping more or less.



GOLDEN OAK SCALE

Fig. 11.—1. An oak twig sparsely infested with the small oval golden yellow scales. 2. A scale much enlarged as it appears under a magnifying glass. 3. A portion of a twig somewhat enlarged showing the circular pits produced by the scale and the swollen bark around the insect.



OYSTER SHELL SCALE

Fig. 12.—A. Portion of twig showing a sparse infestation. B. One scale enlarged. C. The same turned over and showing the numerous white eggs found therein during the winter. D. A cluster of scales greatly enlarged as they occur upon a tree.

In the summer and fall of 1928 the distribution of the mite was given some attention by different officers of the Entomological Branch. Mr. W. A. Ross and his associates found that the mite was widely distributed in the Niagara Peninsula where it was doing commercial damage in many of the plantations. Strawberry plants showing the characteristic injury were forwarded by Mr. R. Glendenning from Agassiz, B.C., and Mr. R. P. Gorham from Greys Mills, N.B., and examination showed that all plants were infested with the cyclamen mite. Scouting work was carried out by Mr. R. H. Painter and the writer at points within a hundred mile radius of Ottawa and infested plants found in strawberry plantations at the following, rather widely separated, places:— Brockville, Kemptville and Ottawa in Ontario, and Ste. Anne de Bellevue and Ville la Salle in Quebec. Most of the beds infested showed very severe injury, many of the plants being badly stunted and the production of runners greatly reduced.

Judging by the observations made to date by entomoligists scattered over Canada it would seem probable that the cyclamen mite is widely distributed and threatens to become a serious pest of strawberries.

A BRIEF NOTE ON THE OCCURRENCE OF A MERMITHID PARASITE GENUS HEXAMERMIS, IN THE TARNISHED PLANT BUG, LYGUS PRATENSIS L.

R. H. Painter, Entomological Branch, Ottawa

In the early season of 1928, while dissecting adult tarnished plant bugs for developing testes and ovaries, the presence of a mermithid parasite was noted. Specimens of this parasite were sent to Dr. E. M. DuPorte, of Macdonald College, and to Dr. N. A. Cobb of the United States Bureau of Plant Industry, and were determined by both as belonging to the genus *Hexamermis*.

The presence of this parasite was first noticed on May 23 and individuals were found until about the end of June. The following table gives the numbers recovered and the number of adults dissected:

Date	Free Adults	Parasitized Adults	Total
May 23	3	3	6
" 30	5	4	9
June 7	4	10	14
" 13	0	1	1
" 20	2	1	3
	14	19–57.57%	33

Externally, adults infested with this worm have the following appearance: —The abdomen is much distended, has a tendency to droop noticeably and the

Fig. 1.—Showing *Lygus pratensis* L. adults with *Hexamermis* sp. in situ in the abdomen.

integument between the tergites and sternites is quite noticeable in those in which the worms have reached a length of between 1-2 inches.

On opening up the abdomen of an infested individual the worm is usually found coiled about the intestinal tract, the number of convolutions depending upon the size of the parasite. In some cases the parasite may extend into the thorax, but in general it is confined to the abdomen. In parasitized adults there is always a lack of development of either the ovaries or the testes, as the case may be, and this sterilization is undoubtedly due to the presence of the parasite.

The parasite itself is a typical nematode, specimens ranging from $^3/_4$ of an inch to about 2 inches in length having been taken. It is creamy white in colour, shining, and is bluntly pointed at each end.

It is interesting to note all the parasite specimens of this in the vicinity of Ottawa, Ontario, came from a particular locality. This was an area of about 200 acres of wasteland grown largely to goldenrod. This land was very poorly underdrained and in the spring was very swampy, and throughout the season was more or less wet. Only three specimens were taken outside of this area and these on higher ground about 300 yards distant. The data suggest that this parasite occurs only in low lying land of a more or less wet nature, as counts from different points throughout the vicinity were made during the season and no parasitism noted.

The note, as far as is known, is the only record of parasitism of *Lygus pratensis* L. by a nematode parasite.

EXPERIMENT ON THE VALUE OF "DIPDUST AS A DISINFECTANT FOR SEED POTATOES

B. Baribeau, District Inspector, Laboratory of Plant Pathology, Ste-Anne de la Pocatiere, Que.

At the request of Mr. H. T. Gussow, Dominion Botanist, in the spring 1928, an experiment was undertaken on the farm of Mr. L. A. Ménard, R. R. 1, L'Islet, Co. L'Islet, P. Q., in order to determine the value of "Dipdust" as a disinfectant for seed potatoes in view of controlling *Rhizoctonia*.

The soil of Mr. Ménard's farm, where the experiment was undertaken, was apparently uniform in regard to drainage, fertility, etc. In order to eliminate as much as possible any difference which might arise from irregular distribution of the *Rhizoctonia* organism in the soil, the treatments with their checks, were made in duplicate. The arrangement of the plots was such that each treatment was not adjacent to its duplicate. In this way each treatment was well distributed throughout the experimental area.

Materials:—Corrosive sublimate was used in comparison with "Dipdust".

These two disinfectants were tried in duplicate with healthy and diseased tubers. Each plots contained 100 hills, giving 200 hills test for each treatment and the checks. About 10 tons of barn manure was applied per acre and no

commercial fertilizer was used. The planting of this experiment was made on June 19th and 20th.

Seed Employed.

In order to secure healthy tubers and tubers affected with *Rhizoctonia*, selection by hand was made from Mr. Ménard's potatoes, care being taken to keep the healthy tubers and those affected with the disease separate. The diseased seed was so selected that at least one-third (1-3) of the surface was covered with sclerotia. The results of this selection showed 5% severe infection 30% moderately infected and the remaining 65% slightly infected, this insured that each seed piece was well infected.

Treatment.

All the treatments were made the same day, this being one day previous to planting, as follows: two lots of *Rhizoctonia* infected seed and two lots of healthy seed were treated, before cutting, with corrosive sublimate 1:1000, for two (2) hrs., and four other lots, two healthy and two diseased were treated with "Dipdust", 1 lb. in 2½ gallons of water for one minute, and two lots of Rhizoctonia infected seed and two of healthy seed, left untreated, as checks.

Observations during growing period.

On July 9th, the potatoes treated with "Dipdust" showed a better and more uniform appearance than those treated with corrosive sublimate, or untreated. At that time, no signs of *Rhizoctonia* were observed in any of the experimental plots. The plants in the plots planted with seed treated with corrosive sublimate showed a slower germination. On August 1st, no difference could be noted in either of the plots. There was more rain during the season than in an ordinary year, with heavy rains in June and July. September was rather fine.

Harvesting.

The harvesting of these potatoes was made on October 1st and 2nd, and the tubers harvested in each plot were weighed separately. Observations were also made, in each plot, in order to determine the percentage of healthy and diseased tubers.

Results.

The data are based on the yields obtained and on the percentage of *Rhizoctonia*-infected and *Rhizoctonia* free potatoes for the average of the duplicate plots. The results are summarized in the following table:

RESULTS OF EXPERIMENT WITH IRISH COBBLER VARIETY

—	Clean tubers %	– 3 – Rhizoctonia Tubers			– 4 – Yield per 200 Hills	
		Slight %	Mod-erate %	Severe %	Total Yield lbs.	Marketable yield lbs.
Rhizoctonia seed treated with HgCl2, 1:1000 for 2 hrs	12.5	76	11.5	.....	213.	142.
Rhizoctonia seed treated for 1 minute with Dipdust 1 lb. in 2½ galls. of water	14.	72	10.	.....	258.	175.
Control Rhizoctonia seed untreated.	8.	64	22.5	.....	211.	145.
Clean tubers treated with HgCl2, 1:1000 for 2 hrs	10.	80.5	9.5	.....	291.	190.
Clean tubers, treated for 1 minute with Dipdust 1 lb. in 2½ galls. water	16.5	71.5	11.	1.	273.	164.
Control, clean tubers untreated	8.5	65.	20.	6.5	269.	172.

A glance at the 4th column clearly shows that a difference in yield occured as a result of the various treatments. In fact, there was a marked reduction in the yield caused by the disease. The healthy seed, both treated and untreated produced better yields than the *Rhizoctonia* seed untreated and treated. It is interesting to note, in column 4, that the yield of *Rhizoctonia* seed untreated is 29 lbs. less for the 200 hills than that of the clean seed untreated. In the 2nd column, it is seen that the *Rhizoctonia*-infected seed treated with Dipdust yielded more *Rhizoctonia* free potatoes than healthy seed untreated. On the other hand, the diseased seed and the healthy seed treated with "Dipdust" yielded more disease free potatoes than the diseased seed and the healthy seed treated with corrosive sublimate.

Remarks.

It is difficult, even impossible, to draw practical conclusions on one year's results, but these point to the fact that "Dipdust" may possibly be a good disinfectant for seed potatoes.

Our intention is, this spring, under the supervision of the Dominion Botanist to pursue further experiments to obtain more information, and more exact data on the real value of this disinfectant in order to ascertain whether it is advantageous or not to recommend and use it as a disinfectant for seed potatoes in preference to other disinfectants. For the time being, we are pleased to

make a report of one year's results by using the figures obtained to draw the following conclusions:

Summary.

The average yield of the plots planted with *Rhizoctonia* infested seed and treated with "Dipdust" and corrosive sublimate gave a good increase in favour of "Dipdust", and also an increase over the check plots.

The highest percentage of *Rhizoctonia*-free potatoes was obtained by treating the seed with Dipdust.

Dipdust is a great saving of time and labor and substantially increases the yield when used on Rhizoctonia seed.

THE STEM SPOT OF ONIONS

By J. E. Machacek, Dept. of Plant Pathology, Macdonald College

During late summer of 1928 the writer observed on the seed stalks of some onion plants grown at Macdonald College a very destructive disease. The onions were grown for seed purposes. The same plants had been attacked by downy mildew, *Peronospora schleidenii*, during the summer, but survived the attack and grew vigorously afterwards. During the latter part of August, after a very wet summer, the stem spot disease first began to appear, initially in the old lesions left by the invasions of the downy mildew but later on the healthy portions of the same or other, previously uninjured stalks. The disease increased with alarming rapidity until every seed stalk in the field became badly diseased. An investigation was therefore carried out to determine the nature of the disease, its effects on seed germination, the possibility of seedling infection, and also to observe if any storage rot in the bulbs resulted from the summer infection.

Symptoms.

The first sign of the presence of the disease is the formation of somewhat irregular, oval, pale-green, and somewhat sunken spot upon the seed stalk. The majority of the plants become infected at or just above the bulging part of the seed stalk. Leaves do not appear to be subject to the attacks of the fungus, as only a few small spots were seen. Later in the season the fungus invades the entire seed talk, with the result that the plant is unable to support

the heavy seed head and breaks over. As this breaking-over of the stalk often takes place before the seed is mature the vitality of the seed is necessarily impaired and the rate of germination is decreased. However, with the conditions in which the disease was studied the majority of the seed stalks matured the seed shortly before the break-over and the seed suffered little damage if it was harvested at once.

The conidial stage of the fungus appears soon after the formation of the lesion. The conidia are numerous, forming distinct, dark, concentric rings of fructification on the surface of the lesions. These rings are generally well-marked, though there is a more or less uniform development of the conidia over the central portion of the lesion. Isolation and culturing showed that the fruiting stage was a Macrosporium, later identified as *Macrosporium parasiticum* Thumen.

The perithecial stage,identified as *Pleospora herbarum* (Pers.) Rabenhorst, was developed during the first two weeks in September, and the perithecia continued to develope and increase in numbers as long as climatic conditions permitted. The perithecia first appeared in the lesions, but later were formed more or less generally over the entire seed stalk above the surface of the soil. They grew in irregular concentric rings when formed in the lesions, but irregularly after the host had been killed. The perithecia were very numerous, 150-400 being found per square centimeter. An examination of the perithecia revealed no development of asci, but only of the ascogenous cushion at the base of each perithecium. However, some perithecia on material collected from the field after the first frost, and kept in a moist chamber in the laboratory for a few days, showed that, in a few cases, fully developed asci had formed in the perithecia. When the host had overwintered on the field, and then some of the infected material was placed in a moist chamber, all the perithecia produced asci in abundance. On the field the asci were not formed in large numbers until after April 17th. It is to be remembered that the temperature during this spring was higher than usual at the same date. An abundance of asci can be found when a water-mount is made of the material. Ascospores, typically yellow-brown, muriform, ovate or spindle-shaped, are formed in one or two rows within the ascus. Upon germination the ascospores formed a mycelium bearing the typical Macrosporium conidia.

Review of Previous Work.

There appears to be a great deal of controversy in naming the fungus causing the disease under discussion. Numerous investigators have labelled their specimens under different names. An investigation of the data available showed that most of these names are synonymous. There are several Pleospora species found on the onion plant, but the differences appear to be mostly superficial, due probably to differences in the environment.

Miyake (1), in 1889, showed that *Macrosporium parasiticum* was the imperfect stage of *Pleospora herbarum*. His description of the pathogen agrees very closely with that of the fungus responsible for the local onion disease. Miyake was able to show that the fungus was definitely pathogenic and parasitic to the onion, not just a secondary semi-parasitic saprophyte following in the wake of invasions of the host by the downy mildew fungus, *Perenospora schleidenii*. On the other hand Shipley (3), having spent some time in the investigation of this disease, reported that he had never observed any of this Macrosporium infection on any other onion plants but those which had already been attacked to some degree by the mildew. Since then there has been a definite lull in research concerning this disease, though a few very scattered and minor reports of Macrosporium onion leaf spots have been made from time to time.

Experimental Work.

An experiment to determine if the fungus was carried by the seed of onions was made. It was thought very probable, since the infection was so general, that the seed would carry spores of Macrosporium on its surface, even if no internal infection was found. This theory was proved by experiment.

Two varieties of onion, Red Weathersfield and Red Globe, both of which had proved to be extremely suspectible to attack, were used. The seed was surface-sterilized in the usual manner with corrosive sublimate, and then plated out on solid potato-dextrose agar in Petri dishes. These plates were kept at room temperature. Though the seed was examined every day, for several days after the seed had commenced to germinate, no infection in the form of fungus growth was observed. The experiment was repeated with both varieties of onions, but the results were the same. It was therefore concluded that onion seed, such as was used, was not infected internally by the pathogen.

A similar experiment, but using unsterilized onion seed, was made. After three days it was possible to distinguish a growth of a heterogenous collection of micro-organisms, but the mixture was such as to render impossible the making of a definite conclusion regarding the possible dominence of any single organism. However, isolations of some of the fungi were made, and after growth in pure culture, it was found that at least ten per cent of the seed carried spores of *Macrosporium parasiticum*. The plating out of the washings from seed washed with sterile water also showed that this fungus was present in moderate quantities.

It was thought that, as the fungus can live readily away from its host, that it could exist in soil and be responsible for a "damping-off" of the young onion seedlings. No soil tests were made, but the following experiment was carried out.

The seed of the two varieties of onions was surface-sterilized as before, but instead of plating, the seed was placed on agar slants in test-tubes. The seed

Fig. 1.—Diseased onion seed stalks showing lesions caused by the attacks of *Macrosporium parasiticum.*

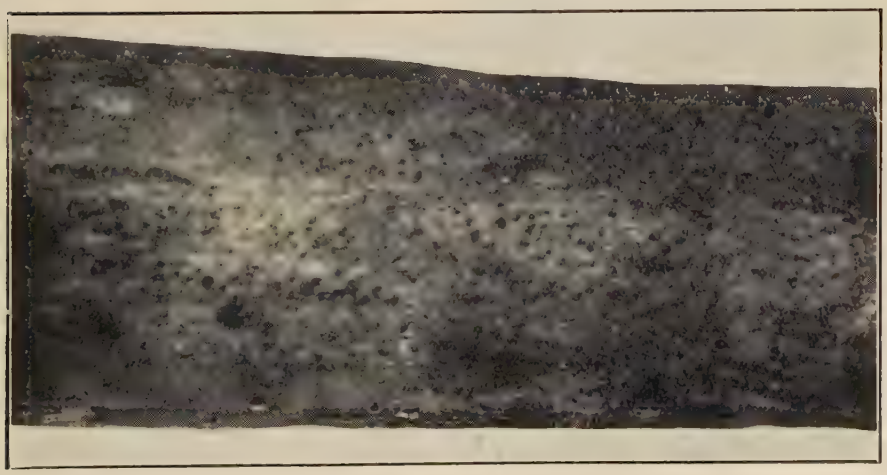


Fig. 2.—Diseased onion stalk showing conidial growth and perithecia.

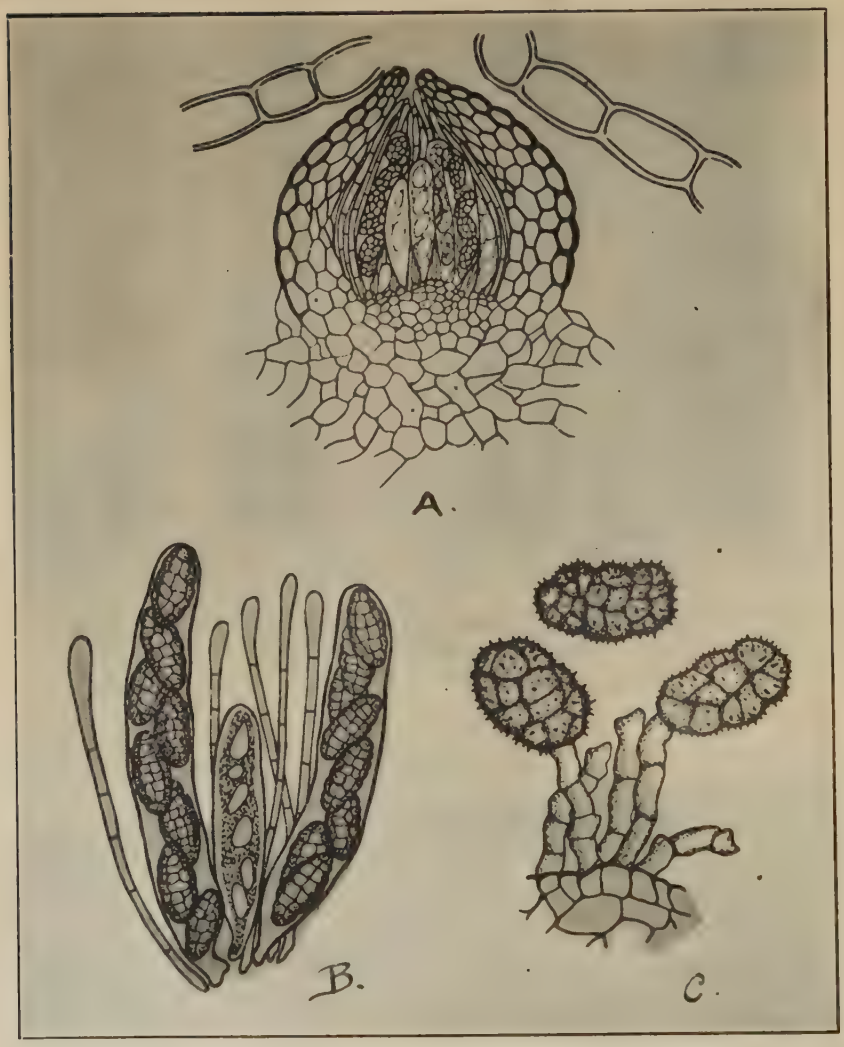


Fig. 3.—*Pleospora herbarum.* (a) Section of perithecium; (b) Asci and paraphyses; (c) Conidial stage.

was allowed to germinate, and after the seedling was approximately one centimeter in length, the agar near the base of the seedling was inoculated with spores from a pure culture of *Macrosporium parasiticum*. The test-tubes were then placed upright in racks and placed in a dark incubator kept at room temperature. The fungus spread rapidly over the surface of the medium but caused no immediate visible change in the seedlings. After a period of approximately ten days a wilting was observed in some of the seedlings, but the fungus was not held directly responsible for that condition. It appeared that the possibility of lack of plant food in the medium for both the fungus and plant host was greater than the possibility of direct infection as the direct cause of the wilt. When the experiment was repeated, but with the test-tubes kept in light, the wilting was somewhat delayed, but the general effect was the same. The dead tissue of the seedlings was examined and some fungus mycelium was found, but this internal growth of hyphae appeared to follow the initial killing of the seedling by one or both of the above agents.

Later in the season an examination of onion bulbs from the infected field was made. These bulbs were placed in cold storage after harvesting, and outside of a small percentage of the bulbs being rotted by neck-rotting fungi, there was no evidence of internal infection Macrosporium. It does not appear possible, then, that under local conditions, the disease will cause very serious damage to seedlings or bulbs, but if major damage is found, it will be through the decrease in vitality and quality of the seed.

Control.

The fungus *Macrosporium parasiticum* is not injurious enough to demand constant attention. The damage can become serious if proper precautions are not taken. The disease can be kept in check by spraying the onion plants with standard Bordeaux mixture, but this application must be made before the disease has become widespread. After the seed stalk has been invaded, the disease rapidly progresses and remedial measures are of no avail. Seed sterilization is recommended, but it is possible that the fungus is already present in the soil in large quantities so that seed sterilization may be of a temporary nature.

Crop rotation and burning of the diseased refuse are secondary aids in preventing the spread of the disease.

In order to diminish the loss to the crop the onion seed should be harvested as soon as ripe, for when the stalks are invaded by the fungus they soon collapse and the seed is brought into contact with the soil, which if wet will cause the seed to germinate before the seed can be harvested. Most of the seed stalks will ripen the seed even after they have been broken down, so that such seed can be salvaged in good condition if collected before it has become damaged by rain.

Summary.

1. An investigation was made on the onion seed stalk spot disease caused by the imperfect stage of the ascomycete, *Pleospora herbarum* (Pers.) Rabenhorst.

2. The asexual stage of the fungus is parasitic usually, but not always, following an attack of the host by the downy mildew fungus, *Peronospora schleidenii.*

3. Asci may be formed in the autumn, but the majority are developed the following spring.

4. The fungus is carried externally on the seed, but not internally.

5. Damping-off of seedlings does not originate through the action of this parasite.

6. Rotting of bulbs in storage by the fungus has not been observed.

7. Control of the disease is possible through spraying and field sanitation. Losses to the seed crop can be reduced by harvesting as soon as the seed is ripe.

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FIG. 1.—Diseased onion seed stalks showing lesions caused by the attacks of Macrosporium parasiticum.

FIG. 2.—Diseased onion stalk showing conidial growth and perithecia.

THE EFFECT OF GYPSUM UPON THE GROWTH AND COMMON SCAB OF THE POTATO

By John G. Coulson, Macdonald College, Que.

The making of applications of gypsum to the soil for the purpose of increasing crop yields has been practiced in Europe and America for many years with variable results. In many cases so striking have been the increases in yield that some have looked upon gypsum as a powerful plant stimulant. A survey of the literature forces one to the conclusion that legumes respond favourably much more consistently than any other crop plants, since most of the increased yields reported have been in connection with the application of gypsum to leguminous crops.

In order to explain the increases often shown, various reasons have been offered such as: liberation of potassium in the soil, addition of the elemental plant foods sulphur and lime in a readily available form, stimulation of the symbiotic bacteria in legumes, improvement of soil texture by flocculation of the colloidal particles of heavy soils, and neutralizing deleterious substances such as sodium carbonate. The evidence for these claims will not be discussed here. It may be stated, however, that it appears that each of these may be important factors, depending upon the specific conditions in which case one or more may be operative. It is interesting to note that a number of investigators in the United States found favourable results from the use of gypsum upon legumes, to occur on soils low in sulphur and this seems to be correlated with the fact that leguminous plants, particularly alfalfa, require a large amount of sulphur in their growth. The nodules on the roots often show a greater development and alfalfa increased by gypsum gives a higher percentage of nitrogen. This suggests that the gypsum increases the growth of alfalfa, by acting directly as a nutrient in soils poor in sulphur and indirectly through its stimulating action upon the nodule bacteria, increasing their fixation of atmospheric nitrogen.

Very complete reviews and summaries of the literature concerning the effect of gypsum upon plant growth are given by such investigators as Olson and St. John (5), Crocker (2) and Cubbon (3).

The object of this investigation was to study the effects of gypsum upon: (1) the growth of potatoes, (2) the development of common scab of potatoes, caused by *Actinomyces scabies* (Thax.) Gûssow, (3) the growth of the scab organism.

THE GYPSUM USED IN THE EXPERIMENT

The gypsum used throughout was obtained from a large deposit at Plaster Rock, N.B., and was finely ground in a crusher, used for crushing limestone for agricultural purposes. This gypsum is for the most part reddish in colour with some layers greenish and others almost pure white. The following is an average analysis of a number of ground samples:—

Calcium as (Ca)	15. 97%
Calcium as (CaO)	22. 35%
Carbonic acid as (H_2CO_3)	0.879%
Calcium as ($CaCO_3$)	1. 42%
Sulphuric as (SO_4)	45. 46%
Sulphuric as (SO_3)	37. 80%
Sulphuric as ($CaSO_4.2H_2O$)	81. 45%
Potash as (K)	0.284%
Potash as (K_2O)	0.342%
Potash as (K_2SO_4)	0.633%
Phosphorous as (P)	0.017%
Phosphorous as (P_2O_5)	0.039%
H-ion concentration of gypsum extract	pH 7.70

This analysis seems to compare favourably with a number of those reported for other natural deposits of gypsum which have been used in agriculture.

Pot Experiment.

On June 21st, 1927, several nine inch pots were filled with a weighed amount of earth treated with gypsum and a 4-8-6- fertilizer at various rates of application per acre (2,000,000 pounds of soil). The material in each case was thoroughly mixed with the soil, which was a fine clay loam of good fertility. Each treatment comprised ten pots, each of which was planted with a single Green Mountain tuber weighing approximately three ounces, taken from a uniform lot. The potatoes were placed in the greenhouse until they were well up and then moved outside to a suitable location. The pots of the various treatments were intermixed and given a different arrangement a number of times during the summer, so as to overcome the chance of any treatment coming under a set of conditions different from the rest. On September 9th, the potatoes were harvested and counts made as given in Table 1. A potato was called scabby if it showed any scab whatever.

TABLE I.—Influence of Gypsum upon Scab Infection (Pot Experiment)

Treatment—lbs. per acre	No. Healthy	No. Scabby	Total	Percent Scabby
No treatment	56	18	74	24.3
Gypsum 250; fertilizer none	31	31	62	50.0
Gypsum 500; " "	30	26	56	46.4
Gypsum 1000; " "	26	30	56	53.5
Gypsum 2000; " "	34	22	56	39.4
Gypsum 3000; " "	26	18	44	40.9
Gypsum none; " 2000	64	16	80	20.0
Gypsum 250; " 2000	46	20	66	30.3
Gypsum 3000; " 2000	38	12	50	24.0

The results point to the conclusion that the gypsum does not arrest potato scab development and seems to show a tendency to reduce the number of tubers per plant. The pots treated with gypsum alone show a striking increase in scab, while those having fertilizer alone or fertilizer and gypsum gave results much closer to the checks. As this type of test is subject to great variability, it is realized that one cannot draw definite conclusions from one experiment.

Field Experiment.—1927.

For this experiment a piece of land of excellent texture for potatoes, 416 ft. by 124 ft., at Plaster Rock, N.B. was used. This soil, which is cleared bush

land, had been under cultivation for eight years and had grown in order four crops of potatoes, one of oats seeded with a mixture of timothy, red clover and alsike and left in hay for three years. A 5-8-7 fertilizer was applied at the rate of 1400 lbs. per acre when planted to potatoes. When seeded to hay, one ton of ground limestone per acre was used. It had never received green manure, straw or manure and had given high yields with all crops grown. Plowing had always been done with a reversible plow and dead furrows have never occurred on the land which has good drainage with practically no slope. The soil was a gravelly sandy loam containing a large percentage of shale stone, and low in organic matter. The soil varied a good deal in colour, due to the burning of stumps and brush when the land was cleared. This land was plowed and cultivated immediately before planting. The last year this area was planted in potatoes it produced about fifty per cent scabby tubers. The acidity of the soil, as determined from a number of samples, was very uniform, giving an average value of pH 6.7.

The planting was done according to the plan given below on June 4th, to 6th, 1927, so that the rows ran practically north and south. This made them run with the usual way of plowing and across the usual way of planting. The rows were 108 ft. long and thirty inches apart. Each check and treatment comprised four rows per plot with four replications. The planter was run without the covering disks in operation which placed the seed pieces uncovered in each row. It was easy, then, to check up for misses or unevenness in planting. Where gypsum was applied the proper amount according to the rate of application was weighed out and applied in the row by hand. This placed the gypsum in contact with the tuber piece. After this the planter with the disks in operation was again run down the row in order to cover the potatoes. The potatoes were planted twelve inches apart using two ounce pieces of Green Mountain Certified Seed, which ran ninety-nine per cent free of all diseases the previous year. The seed pieces all showed more or less scab but no piece was used unless it showed a good sprout. Scabby tubers were used with the idea that this might enhance the opportunities of obtaining scab infections upon the tubers of the succeeding crop.

Plan of Planting

Check-1	A – 250 lbs.	Check-2	A – 500 lbs.	Check-3	A – 1000 lbs.	Check-4	A – 2000 lbs.	Check-5	A – 3000 lbs.	Check-6	B – 3000 lbs.	Check-7	B – 2000 lbs.	Check-8	B – 1000 lbs.	Check-9	B – 500 lbs.	Check-10	B – 250 lbs.	Check-11
C – 3000 lbs.	Check-12	C – 2000 lbs.	Check-13	C – 1000 lbs.	Check-14	C – 500 lbs.	Check-15	C – 250 lbs.	Check-16	D – 250 lbs.	Check-17	D – 500 lbs	Check-18	D – 1000 lbs.	Check-19	D – 2000 lbs.	Check-20	D – 3000 lbs.	Check-21	

The potatoes were harvested on Sept. 19th to 25th, 1927, using two rods in each of the two centre rows of each check and treatment plot. The number of hills were counted in each two rods harvested; the tubers were divided into

marketable and culls according to size, and the number and weight of scabby and healthy tubers determined in each class. A potato was called scabby that showed even a single small spot, so that a tuber was often designated as scabby which would pass as healthy on the market.

Since the soil was to receive calcium and sulphur in the form of gypsum, a number of samples of the soil to a depth of ten inches were taken previous to planting in various parts of the field for the purpose of chemically analysing these to determine their content with respect to these elements, even though it was relized that such chemical analyses are no definite index as to fertility of soil, excepting in certain cases such as where marked deficiencies occur. This gave as an average result:—

CaO		0.39%
SO_3	total S	0.14%

According to the report of the Dominion Chemist for 1925 "light and sandy loams containing less than 0.25% lime (CaO) and clay loams less than 0.5% will as a rule have their productiveness increased by a dressing of lime in one or other of its agricultural forms". Since this is a sandy loam it would not appear to be deficient in lime. The sulphur content also seems to be satisfactory when compared to the findings of Robinson (6), who reports that the total sulphur found in twenty-six types of American soils ranged from 0.03% SO_3 to 0.39% SO_3 with an average of 0.13%. Also Swanson and Miller (8) found the average sulphur content of the upper seven inches of Kansas soils to be 0.046% as sulphur in virgin soils and 0.027% in cropped soils, and quote evidence that sulphur applied in the form of potassium sulphate has not increased the yield of alfalfa or other crops.

TABLE 2.—Gypsum Experiment — Data relating to numbers of Tubers—(Field Test 1927)

Treatment Gypsum	Number of Hills	Marketable			Culls			Totals			Average Number of Tubers per Hill
		Healthy	Diseased	Total	Healthy	Diseased	Total	Healthy	Diseased	Total	
250 lbs. per acre A	59	132	40	172	93	26	119	225	66	291	
B	57	112	30	142	84	31	115	196	61	257	
C	62	103	47	150	97	31	128	200	78	278	4.5
D	62	117	18	135	102	19	121	219	37	256	
	240	464	135	599	376	107	483	840	242	1082	
Av.	60	116	33.75	149.75	94	26.75	120.75	210	60.5	270.5	
500 lbs. per acre A	64	135	33	168	89	25	114	224	58	282	
B	58	103	38	141	72	28	100	175	66	241	
C	58	54	63	117	88	31	119	142	94	236	4.1
D	62	89	35	124	84	35	119	173	70	243	
	242	381	169	550	333	119	452	714	288	1002	
Av.	60.5	95.25	42.25	137.5	83.25	29.75	113	178.5	72	250.5	
1000 lbs. per acre A	65	115	43	158	72	39	111	187	82	269	
B	64	97	34	131	55	37	92	152	71	223	
C	64	64	77	141	69	44	113	133	121	254	3.9
D	61	93	26	119	83	31	114	176	57	233	
	254	369	180	549	279	151	430	648	331	979	
Av.	63.5	92.25	45	137.25	69.75	37.75	107.5	162	82.75	244.75	
2000 lbs. per acre A	67	89	47	136	53	31	84	142	78	220	
B	55	92	46	138	55	22	77	147	68	215	
C	66	48	80	128	60	42	102	108	122	230	3.6
D	60	84	38	122	70	31	101	154	69	223	
	248	313	211	524	238	126	364	551	337	888	
Av.	62	78.25	52.75	131	59.5	31.5	91	137.75	84.25	222	

TABLE 2. — (Continued from previous page)

3000 lbs. per acre	A	57	64	66	130	48	38	86	112	104	216	
	B	61	65	75	140	64	42	106	129	117	246	
	C	59	65	86	151	50	29	79	115	115	230	3.8
	D	63	65	76	141	64	25	89	129	101	230	
		240	259	303	562	226	134	360	485	437	922	
	Av.	60	64.75	75.75	140.5	56.5	33.5	90	121.25	109.25	230.5	
Check	1	.....	50	16	66	38	9	47	88	25	113	
"	2	63	125	39	164	97	39	136	222	78	300	
"	3	62	120	37	157	99	17	116	219	54	273	
"	4	59	100	32	132	95	37	132	195	69	264	
"	5	61	119	24	143	103	35	138	222	59	281	
"	6	58	113	25	138	89	33	122	202	58	260	
"	7	63	102	31	133	124	37	161	226	68	294	
"	8	65	101	37	138	102	32	134	203	69	272	
"	9	61	67	43	110	110	48	158	177	91	268	
"	10	60	94	27	121	84	35	119	178	62	240	
"	11	58	104	55	159	136	31	167	240	86	326	4.6
"	12	58	94	39	133	88	34	122	182	73	255	
"	13	65	103	39	142	107	46	153	210	85	295	
"	14	62	96	34	130	132	38	170	228	72	300	
"	15	62	108	41	149	116	39	155	224	80	304	
"	16	59	101	47	148	107	25	132	208	72	280	
"	17	62	119	27	146	116	32	148	235	59	294	
"	18	59	106	26	132	142	38	180	248	64	312	
"	19	61	95	33	128	111	41	152	206	74	280	
"	20	63	104	42	146	125	34	159	229	76	305	
"	21	64	79	36	115	97	20	117	176	56	232	
		1225	2050	714	2764	2180	691	2871	4230	1405	5635	
	Av.	61.3	102.5	35.7	138.2	109	34.55	143.55	211.5	70.25	281.75	

N. B.—In Check 1 only one row was counted. These figures not used in calculating averages.

LAND PLASTER EXPERIMENT—1927

Conducted at Plaster Rock—N.B.

POTATOES

TABLE 3.—GYPSUM EXPERIMENT—Summary of Data Relating to Scab Infection.—(Field Test 1927)

Treatment	% infection					Difference	Difference P. E.
	A	B	C	D	Average		
Check	22.12	25.83	26.32	25.71*			
250 lbs. per acre	22.68	23.74	28.06	14.45	22.23 ± 1.34	2.40 ± 1.75	1.37
Check	26.00	26.38	25.71*	20.07	24.63 ± 1.12		
Check	26.00	33.96	24.00	20.07			
500 lbs. per acre	20.57	27.39	39.83	28.81	29.15 ± 1.75	4.59 ± 2.03	2.26
Check	19.78	25.83	26.32	20.51	24.56 ± 1.04		
Check	19.78	25.37	28.81	20.51			
1000 lbs. per acre	30.48	31.84	47.64	24.46	33.60 ± 2.02	7.98 ± 2.29	3.48
Check	26.14	33.96	24.00	26.43	25.62 ± 1.09		
Check	26.14	23.13	28.63	26.43			
2000 lbs. per acre	35.45	31.63	53.04	30.94	37.76 ± 2.27	12.20 ± 2.52	4.84
Check	21.00	25.37	28.81	24.92	25.56 ± 1.09		
Check	21.00	22.31*	26.38	24.92			
3000 lbs. per acre	48.15	47.56	50.00	43.91	47.40 ± 2.85	23.04 ± 3.06	7.53
Check	22.31*	23.13	28.63	24.14	24.36 ± 1.11		

* Used only once in calculating average.

Differences of 3.2 times the probable error (last column) gives odds of over 31 to 1. Such odds are considered significant.

According to Table 2 the number of tubers per plant was decreased with the gypsum applications. These figures refer only to the number of tubers infected irrespective of the extent of infection. While the total number of tubers per plot was reduced, the number of marketable tubers remained practically constant, resulting in an increase in the percentage of marketable tubers. These effects were most noticeable with the heavy treatments.

Table 3 gives the percentage scab infection with the various treatments compared to their related checks. The figures indicate that with increasing amounts of gypsum applied, there is an increased amount of scab infection. In the case of 250 and 500 pound treatments, however, the differences between the treatment plots and checks have no significance. A tuber with one small spot has as much influence in these figures as a severely infected tuber. At time of harvest it was observed that with the 1000, 2000 and 3000 pound treatments the infected tubers were more covered with scab than in the lower treatments and checks.

TABLE 4.—GYPSUM EXPERIMENT—Data Relating to Yields—(Field Test 1927)

Treatment Gypsum		Marketable in lbs.			Culls in lbs.			Totals in lbs.			Per cent Marketable		Yields per acre in bushels		
		Healthy	Diseased	Total	Healthy	Diseased	Total	Healthy	Diseased	Total	Healthy	Total	Total	Marketable	Healthy Marketable
250 lbs. per acre	A	34.	9.75	43.75	8.	2.25	10.25	42.	12.	54.	62.96	81.02			
	B	29.	5.25	34.25	9.5	3.25	12.75	38.5	8.5	47.	61.70	72.87			
	C	23.25	9.75	33.00	9.25	2.25	11.50	32.5	12.0	44.5	52.25	74.16			
	D	25.	5.5	30.50	10.00	1.75	11.75	35.	7.25	42.25	59.17	72.19			
		111.25	30.25	141.50	36.75	9.50	46.25	148.	39.75	187.75	236.08	300.24	206.53	155.02	121.89
	Av.	27.81	7.56	35.38	9.19	2.38	11.56	37.	9.94	46.94	59.02	75.06			
500 lbs. per acre	A	30.75	9.	39.75	8.	1.75	9.75	38.75	10.75	49.50	62.12	80.30			
	B	28.	11.	39.	5.25	2.5	7.75	33.25	13.5	46.75	59.89	83.42			
	C	10.	14.75	24.75	8.	3.25	11.25	18.	18.	36.	27.78	68.75			
	D	17.	6.75	23.75	7.	3.	10.	24.	9.75	33.75	50.37	70.37			
		83.75	41.5	127.25	28.25	10.5	38.75	114.	52.	166.	200.16	302.84	182.6	138.22	91.37
	Av.	21.44	10.38	31.81	7.06	2.63	9.69	28.5	13.	41.5	50.04	75.71			
1000 lbs. per acre	A	23.	8.75	31.75	3.5	3.	6.50	26.5	11.75	38.25	60.01	83.01			
	B	25.5	8.	33.5	5.	2.5	7.50	30.5	10.5	41.	62.19	81.71			
	C	12.75	17.5	30.25	5.75	4.25	10.	18.5	21.75	40.25	31.68	75.16			
	D	20.5	5.	25.5	6.5	3.25	9.75	27.	8.25	35.25	58.16	72.34			
		81.75	39.25	121.	20.75	13.	33.75	102.5	52.25	154.75	212.04	312.22	170.23	132.86	90.24
	Av.	20.44	9.81	30.25	5.19	3.25	8.44	25.6	13.06	38.69	53.01	78.05			
2000 lbs. per acre	A	21.75	11.5	33.25	3.25	2.	5.25	25.	13.5	38.5	56.49	86.36			
	B	24.5	13.75	38.25	6.5	1.5	8.	31.	15.25	46.25	52.97	82.70			
	C	10.	18.	28.	5.	4.	9.	15.	22.	37.	27.03	75.67			
	D	17.5	7.75	25.25	5.	3.25	8.25	22.5	11.	33.5	52.24	75.37			
		73.75	51.	124.75	19.75	10.75	30.5	93.5	61.75	155.25	188.73	320.10	170.78	136.65	80.57
	Av.	18.44	12.75	31.19	4.94	2.69	7.6	23.4	15.44	38.81	47.18	80.02			

TABLE 4.—(Continued from previous page)

3000 lbs. per acre	A	15.25	16.75	32.	3.5	2.	5.5	18.75	18.75	37.5	40.67	85.33			
	B	14.25	16.75	31.	4.5	2.	6.5	18.75	18.75	37.5	38.00	82.67			
	C	16.25	21.5	37.75	5.5	4.25	9.75	21.75	25.75	47.5	34.21	79.47			
	D	12.75	14.25	27.	4.75	2.5	7.25	17.5	16.75	34.25	37.23	78.83			
		58.5	69.25	127.75	18.25	10.75	29.	76.75	80.	156.75	150.11	326.30	172.42	140.65	64.71
	Av.	14.63	17.31	31.94	4.56	2.68	7.25	19.18	20.	39.19	37.53	81.58			
Check	1	21.5	9.	30.5	5.25	3.25	8.5	26.75	12.25	39.	55.13	78.20			
"	2	29.	10.75	39.75	9.	4.5	13.5	38.	15.25	53.25	55.50	74.65			
"	3	27.25	7.	34.25	8.	1.	9.	35.25	8.	43.25	63.00	79.19			
"	4	20.25	6.5	26.75	7.75	1.75	9.50	28.	8.25	36.25	55.86	73.79			
"	5	26.75	5.	31.75	7.25	1.75	9.	34.	6.75	40.75	65.64	77.91			
"	6	25.5	4.	29.5	7.	1.75	8.75	32.5	5.75	38.25	66.67	77.12			
"	7	22.	4.	26.	10.	2.75	12.75	32.	6.75	38.75	54.19	66.45			
"	8	24.5	6.75	31.25	8.5	2.75	11.25	33.	9.5	42.5	57.65	73.53			
"	9	15.	11.75	26.75	9.5	4.25	13.75	24.5	16.	40.5	37.04	66.05			
"	10	23.	5.5	28.5	8.75	4.	12.75	31.75	9.5	41.25	55.76	69.09			
"	11	21.	12.	33.	11.5	2.5	14.	32.5	14.5	47.	44.67	70.21			
"	12	21.25	9.25	30.5	6.75	3.5	10.25	28.	12.75	40.75	52.15	74.85			
"	13	20.5	7.5	28.	9.	4.25	13.25	29.5	11.75	41.25	49.70	67.88			
"	14	17.25	6.25	23.5	8.75	2.75	11.5	26.	9.	35.	49.28	67.14			
"	15	20.5	9.25	29.75	9.	3.5	12.5	29.5	12.75	42.25	48.52	70.41			
"	16	20.75	11.25	32.	8.75	2.	10.75	29.5	13.25	42.75	48.54	74.85			
"	17	25.5	5.75	31.25	9.	2.5	11.5	34.5	8.25	42.75	59.65	73.10			
"	18	19.25	4.75	24.	10.25	2.5	12.75	29.5	7.25	36.75	52.38	65.31			
"	19	18.75	6.	24.75	8.5	3.5	12.	27.25	9.5	36.75	53.74	67.35			
"	20	20.	8.	28.	9.5	2.75	12.25	29.5	10.75	40.25	49.69	69.56			
"	21	13.25	6.5	19.75	8.	1.5	9.5	21.25	8.	29.25	45.30	67.52			
		452.75	156.75	609.50	180.	59.	239.	632.75	215.75	848.50	1120.06	150413	177.67	127.27	94.77
	Av.	21.56	7.46	29.02	8.57	2.81	11.38	30.13	10.27	40.40	53.34	71.63			

TABLE 5.—GYPSUM EXPERIMENT—Marketable Tubers in per cent of total on Basis of Weight—(Field Test 1927).

Treatment	Percentages					Difference	Difference P. E.
	A	B	C	D	Average		
Check	78.20	69.09	70.41	74.85 *			
250 lbs	81.02	72.87	74.16	72.19	75.06 ± 1.47	2.13 ± 1.82	1.17
Check	74.65	70.21	74.85 *	73.10	72.93		
Check	74.65	66.05	67.14	73.10			
500 lbs	80.30	83.42	68.75	70.37	75.71 ± 1.49	5.10 ± 1.78	2.86
Check	79.19	69.09	70.41	65.31	70.61 ± 0.98		
Check	79.19	73.53	67.88	65.31			
1000 lbs	83.01	81.71	75.16	72.34	78.05 ± 1.53	8.02 ± 1.81	4.43
Check	73.79	66.05	67.14	67.35	70.03 ± 0.97		
Check	73.79	66.45	74.85	67.35			
2000 lbs	86.36	82.70	75.67	75.37	80.03 ± 1.57	8.61 ± 1.86	4.63
Check	77.91	73.53	67.88	69.56	71.42 ± 0.99		
Check	77.91	77.12 *	70.21	69.56			
3000lbs	85.33	82.67	79.47	78.83	81.58 ± 1.60	9.63 ± 1.92	5.02
Check	77.12 *	66.45	74.85	67.52	71.95 ± 1.07		

* Used only once in calculating average.

Difference of 3.2 times the probable error (last column) gives odds of over 31 to 1. Such odds are considered significant.

On basis of all plots;

P. E. single observation in % =3.9267
P. E. four observations in % =1.9633
P. E. seven observations in % =1.4841
P. E. eight observations in % =1.3883

Figures for the yields are given in Tables 4 and 5. With increasing applications of gypsum there was an increase in the percentage of marketable tubers. The total yield per acre was practically constant throughout. While the yields of marketable tubers per acre in bushels was practically the same for all treatments and somewhat higher than the checks, due to the effect of the increase of scab with the gypsum applications, the yield of healthy marketable tubers was progressively decreased.

Field Experiment—1928.

A second test similar to the one of 1927, at Plaster Rock, was carried out at Macdonald College in a field with quite heavy clay soil. This land has been used for the growing of vegetable crops for several years and was in good fertility. The previous year it grew a crop of potatoes which showed considerable scab. The hydrogen ion concentration of this soil was very constant in a number of samples taken in various parts of the field and gave an average value of pH. 6.9. Some few years ago it had received an application of lime. Table 6 gives the plan of planting and the percentage of scab by numbers on the tubers. The rows were 32 inches apart and the plants 12 inches apart in the row. Three rods were harvested in the part of each row belonging to each section, which was 5 rods of the rows running the length of the field. The tubers were examined for scab as soon as dug and a tuber showing any visible scab was listed as scabby. No yields were determined as the tubers were so badly infected with late blight that they rotted in storage before this could be done.

TABLE 6.—GYPSUM TREATMENT.—Plan of Planting and Percentage Scab Infection (Field Test 1928).

Row number	Section A	Section B	Section C
	Treatment in lbs. per acre and percentage scab	Treatment in lbs. per acre and percentage scab	Treatment in lbs. per acre and percentage scab
1	Filler.....	Filler.....	Filler..... ....
2	Check..... 80.8	Check..... 63.2	Check..... 46.4
3	Lime—2,000.... 62.7	Lime—2000..... 53.9	Lime—2000..... 47.6
4	Check..... 70.8	Check..... 71.5	Check..... 35.2
5	250..... 72.6	1000..... 76	3000..... 45.6
6	250..... 74.2	1000..... 78	3000..... 43.7
7	Check..... 70	Check..... 74.3	Check..... 54.2
8	500..... 75.6	2000..... 59.7	250..... 42.5
9	500..... 76.8	2000..... 57.3	250..... 47.4
10	Check..... 78.9	Check..... 59.2	Check..... 55.9
11	1000..... 71.3	3000..... 80.2	500..... 58
12	1000..... 66.4	3000..... 52.1	500..... 52.2
13	Check..... 79.3	Check..... 65	Check..... 55.8
14	Check..... 73.1	Check..... 68	Check..... 54.6
15	2000..... 48.4	250..... 70.6	1000..... 69
16	2000..... 45.8	250..... 52.4	1000..... 47.5
17	Check..... 74.5	Check..... 57.9	Check..... 43.5
18	Lime—2,000.... 62	Lime—2,000.... 70	Lime—2,000.... 47.9
19	Check..... 90.2	Check..... 66	Check..... 71.5
20	3000..... 70.4	500..... 71	2000..... 55.5
21	3000..... 62	500..... 60	2000..... 47.8
22	Check..... 60.5	Check..... 57.3	Check..... 70.6
23	Check..... 37.3	Check..... 64.7	Check..... 45.7
24	250..... 44.4	1000..... 55.3	3000..... 56.1
25	250..... 51.8	1000..... 52.6	3000..... 48.4
26	Check..... 62.6	Check..... 69.9	Check..... 38.3
27	500..... 70.3	2000..... 62.6	Check..... 54.9
28	500..... 64.3	2000..... 65.6	Check..... 70.9
29	Check..... 75.7	Check..... 69.7	Check..... 63.5
30	Lime—2,000.... 56.7	Lime—2,000.... 50	Lime—2,000.... 51
31	Check..... 63.4	Check..... 70.7	Check..... 59.9
32	Filler.....	Filler.....	Filler..... ....

Average percent scab—Checks	63.30
" " " — 250 lbs. gypsum per acre	56.99
" " " — 500 " " "	66.02
" " " —1000 " " "	64.51
" " " —2000 " " "	55.32
" " " —3000 " " "	57.31
" " " —2000 " lime per acre	55.75

The figures for percentage scab infection in this test were so variable that they do not seem to indicate anything definite. However, it looks as though the various treatments had not had any effect upon the scab infection. A possible explanation for the extreme variability in the amount of scab would seem to be that the scab organism occurs very irregularly in this soil.

EFFECT OF GYPSUM ON SOIL ACIDITY

Samples of the soil of the field at Plaster Rock, N.B. and pot tests were taken before planting and at time of harvesting and the acidity of these determined colorimetrically. In both cases no change occurred in the pH value in any of the treatments. The H-ion concentration of the soil used in the pot experiment was pH 6.8 and of the field soil pH 6.7. Both of these values are very favourable for the development of scab.

In order to test this point further a laboratory experiment was set up using samples of soil from the field at Plaster Rock. One hundred and fifty gram lots of these were treated with gypsum at various rates from 250 to 3000 pounds per acre (2,000,000 pounds of soil), and placed in 500 c.c. flasks plugged with cotton. The soil samples were kept moist throughout and at the end of six months pH determinations were again made and these showed no change in acidity.

Some investigators are of the opinion that gypsum produces acid conditions in the soil. The above results agree with those of Thatcher Streeter and Collision (9), who have found that calcium sulphate when added to plots at Geneva, N.Y., for thirty-three years at the rate of 2000 pounds per acre annually, produced no change in the acidity of the soil. Cubbon (3) also reports that gypsum did not alter the pH of the soil of his experiments.

EFFECT OF GYPSUM UPON GROWTH OF ACTINOMYCES SCABIES (Thax.) Güss.

In view of the increases in scab produced, where gypsum was applied, an experiment was run to study the influence of gypsum upon the growth of the scab organism. For this gypsum was added to potato dectrose agar in amounts ranging from one half to fifty per cent gypsum, poured into tubes which were then plugged and sterilized. A number of isolations of *A. scabies* were inoculated into several series of tubes kept at room temperature and followed closely for difference in vigour of growth. This was repeated several times, using a large number of cultures, and in no case was any difference due to gypsum observed.

DISCUSSION

The gypsum used has not given any marked stimulative effects upon the potato under the conditions of this experiment. According to Brown and Kellogg (1), the potato uses a higher amount of sulphur for its growth than many other agricultural plants, so that one might expect that applications of material containing sulphur in a readily available form would improve the growth of this crop, at least in soils that were low in this element, similarly to the apparent effect, at times, observed of gyspum upon alfalfa. However, the chemical analysis of this soil is not low in sulphur and, in fact, the soil did not seem to be poor in any characteristic which gypsum has been shown to improve,

so that the field experiment may not constitute a fair test of the value of gypsum when applied to soils poorer in these respects.

The most striking influence of the gypsum was the definite and progressive increase in the percentage scab infection in the field test, at Plaster Rock, with all treatments of 1000 pounds per acre and higher. In the pot experiment all applications of gypsum alone gave an increase of scab. This agrees with the results reported by Shutt (7), who found gypsum to have no deterrent effect on scab and in some cases to have distinctly increased the percent infection. Olson (4) gives evidence to the effect that gypsum controls potato scab and found favourable results with 800 to 1000 pounds per acre. This seems to indicate that the influence of gypsum on potato scab may vary, either with the sample used or the conditions under which the test is made. The gypsum when added to potato dextrose agar showed no observable influence upon the growth vigour of the scab organism in pure culture. From this it would appear that the increased infection was not due to the gypsum stimulating the organism. The H-ion concentration of the soil, in all cases, was very favourable for scab development and no change occurred in its value, in any instance, during the experiment.

It is interesting to note that the usual rate of application of commercial fertilizer which has been made to the field at Plaster Rock when planted to potatoes, had been 1400 pounds per acre of a 5-8-7 mixture and this would supply approximately 350 pounds of calcium sulphate to the acre, figuring the acid phosphate as fifty percent calcium sulphate. From the results given above, it would seem to indicate that this amount might show a tendency to increase scab.

No manure or regular fertilizer was used and it could not be concluded that with customary fertilizer practice the gypsum would give the same results as when used alone.

Much more work needs to be done before reliable and more complete data can be obtained relative to the influence of gypsum upon the potato and this investigation is being continued, with the hope of arriving at more definite conclusions.

SUMMARY

1. Gypsum showed a tendency to reduce the number of tubers per plant.
2. The percentage of marketable tubers increased with increasing rates of gypsum application while the percentage of marketable healthy was reduced.
3. Treatments of 1000, 2000 and 3000 pounds of gypsum per acre in one field test increased the amount of scab development. The amount of scab was correlated with the amount of gypsum applied.
4. In the pot experiment all treatments of gypsum alone increased the scab development.

5. The gypsum did not alter the pH of the soil.
6. The gypsum showed no effect upon the growth of *A. scabies*, when added to potato dextrose agar.

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A PRELIMINARY REPORT ON SIZE OF SEED IN RELATION TO SMUT INFECTION IN OATS

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It is claimed that the critical stage of the oat plant in relation to smut infection is in the early stages of the seedling development shortly following the start of germination. It may be that in the case of vigorous growth the

duration of the critical period is short, while with slow development the duration of the critical period is long, offering a greater opportunity for infection. Therefore, those factors which tend to retard the growth in the early stages of seedling development may be considered to be of importance regarding smut infection.

Investigators, in studying the influence of size of seed in cereals, have found that with small seed a much slower seedling development is obtained than is the case with large seed. Naturally, it was thought that there might be some relation between the size of seed and the amount of smut infection, and in view of such possibilities the experiments herein reviewed were planned.

METHODS

Varieties:—

The work was conducted with three varieties, Banner 4707 M. C., Alaska 412 M. C., and Liberty (0.480). The two first named belong to the A. sativa group, the Banner strain being medium to late maturing and the Alaska strain being early maturing. Liberty (0.480) is a hull-less oat belonging to the group A. nuda.

Seed:—

The seed was graded by means of screens so as to separate out the very large and the very small. In both cases only plump seed was used. The efficiency of the screening was checked over by subsequent hand selection. The difference in the size of seed used is indicated by the 100 kernel weight as shown in Table I.

To eliminate the mechanical protection that the hull offers, seed of Banner 4707 M. C., and Alaska 412 M. C., was dehulled. Seed of Banner 4707 M. C. with hull was also used.

The seed was shaken up with a quantity of smut spores sufficiently large so that the seed was well covered with the spores.

Kinds of Smuts:—

Both Covered and Loose Smuts were used, the Covered in 1924 and 1925 and the Loose in 1926 and 1927 in the field experiments. Both were used in the greenhouse experiments.

Methods of testing:—

The tests were conducted both in the greenhouse, during the winter, and in the field. In the greenhouse the planting was done in sand in flats; in each flat the large and small seed were put in alternate rows using fifty-two seeds of each to the flat. In the field the large and small seed were sown in alternate

plots of 100 in 1924 and 120 seeds in the other years. In the greenhouse four tests were conducted, and in the field five tests in 1924 and three in the other years were conducted for each comparison. The percent infection was determined on the basis of numbers of plants, a partially smutted plant being classified as smutted.

RESULTS

Covered and naked seed:—

The differences in amount of infection resulting when naked as compared with covered seed of Banner 4707 M. C. was used are shown in Table II. The differences are quite marked and are noted with both the large and small seed. These differences are truly significant as there were no exceptions in any individual test. With the small seed there are greater differences between the covered and naked seed than with the large.

Size of seed:—

There was not a significant difference in the amount of Covered Smut found in the comparisons of large and small seed of Banner 4707 M. C. with hull (Table II). But when Loose Smut was used the small seed produced more smutted plants than did the large seed in each of the six comparisons made in 1926 and 1927.

However, it should not be concluded that size of seed is definitively shown to be more important in relation to Loose Smut than to Covered Smut infection. The fact that 1926 and 1927 conditions were very favourable for smut was probably a factor in causing a more marked difference between the large and small seed in those two years than in the two previous years. The statement that there was a greater smut infection in 1926 and 1927 as compared with 1924 and 1925 is based on data obtained in the study of varietal susceptibility to smut conducted by the Agronomy Department.

On the basis of the averages, the size of seed generally had a marked relation to the amount of smut both in the field and in the greenhouse experiments when dehulled, and naturally hull-less seed was used. There were some exceptions however; these were with Banner 4707 M. C. In the field experiments in 1926 when Loose Smut was used a greater infection was obtained from the plots in which large seed was sown; this condition was found in two out of three tests (Table II). With the same variety in the greenhouse experiments (Table III) the large seed gave a larger infection of Covered Smut in three out of four tests

In the remainder of the trials the averages show a greater infection with the small than with the large seed. This condition was found to be markedly consistent in the individual tests. There are four exceptions to be noted, three of which do not materially influence the significance of the results. The import-

ant exception is with Alaska 412 M. C. in the greenhouse experiments with covered smut where, though the average is in favour of the large seed, two out of the four tests are in favour of the small seed (Table III). Two other exceptions are to be noted in the greenhouse experiments. In one of the tests with Banner 4707 M. C. with Loose Smut there was no difference between the large and small seed, and in one of the tests with Liberty (0.480) again with Loose Smut the large seed gave a fraction of one percent more smut than did the small seed. In this case, however, note should be made of the comparatively poor stand in the case of small seed. The other exception to be noted is in the 1926 field experiments with Alaska 412 M. C. when in one test the large seed had 1.64% more Loose Smut than did the small.

DISCUSSION

The results of these experiments show that undoubtedly seedlings from small seed are more susceptible to both the smuts of oats than are those from large seed. The greater infection in the small seed may be due to lower resistance in the less vigorous seedlings or it may be due to the fact that with the less vigorous growth the seedlings from the small seed are in the critical stage for infection for a longer period. There is no information as to whether or not this greater susceptibility is of economic importance over a period of years with seed protected by hull and with ordinary inoculation. However, the results obtained in 1926 and 1927 with covered seed of Banner 4707 M. C. indicate that in some seasons good grading of the seed may be an important factor in reducing the susceptibility of the crop to the diseases in question.

With reference to experimental methods in the study of the relation of the oat plant to both Covered and Loose Smuts the data obtained in these experiments are of value. In the first place, as has been reported by other workers also, it is quite evident that the covering of the kernel by the hull offers protection against infection. Such being the case the apparently greater susceptibility of some hull-less varieties may be due not to lack of resistance to infection but due to the lack of protection as compared with covered varieties. When preparing seed for tests note should be made of the fact that the hull offers protection. The seed of covered varieties, therefore, should be carefully gone over to assure that no naked kernels are present in the lot unless it is desired to remove as much as possible all mechanical protection in which case all the seed should be dehulled.

It is quite clear also that wide differences in infection may result when using seed of varying size. For example, Alaska 412 M. C., which in the tests conducted by the Agronomy Department of Macdonald College has been found to be one of the smut resistant varieties, had in the greenhouse tests with Loose Smut 19.9 and 43.1% infection respectively with large and small

seed. In considering all plants irrespective of the size of seed the percent infection was 31.3. We find then that we have three different figures representing the amount of infection in Alaska. It is obvious, therefore, that uniformity of grading of the seed used is an important factor in obtaining reliable results.

TABLE I.—Size of Seed as Indicated by Weight (in grams) of One Hundred Kernels. (Field Experiments).

—	Banner 4707 M. C. With Hull		Banner 4707 M. C. Without Hull		Alaska 412 M. C. Without Hull		Liberty (0) Hull-less	
	Large	Small	Large	Small	Large	Small	Large	Small
1924	3.97	1.66	2.94	1.44	2.99	1.40	3.17	1.41
1925	3.32	1.68	2.42	1.28	3.14	1.32	2.94	1.22
1926	3.38	1.72	2.60	1.40	2.78	1.45	2.68	1.32
1927	3.52	1.50	2.50	1.20	2.70	1.42	2.70	1.18

TABLE II.—Percent of Smutted Plants Found in Plots Seeded with Seed of Varying Size. (Field Experiments).

—	Banner 4707 M. C. With Hull		Banner 4707 M. C. Without Hull		Alaska 412 M. C. Without Hull		Liberty (0) Hull-less	
	Large	Small	Large	Small	Large	Small	Large	Small
Covered Smut								
1924	2.01	1.75	19.11	35.46	10.95	40.74	40.84	66.14
1925	4.00	7.17	38.44	53.22	8.72	30.36	50.79	73.84
Loose Smut								
1926	6.86	12.66	85.93	81.82	37.04	65.69	75.83	93.47
1927	12.00	27.30	49.01	79.54	21.26	46.63	60.61	79.28

The data in Tables I and II are on the basis of the averages of five tests for 1924 and of three tests in each of the following years. In each of the 1924 tests 100 seeds were used and for the individual tests in the other years 120 seeds were used.

TABLE III.—Size of Seed in Relation to Smut Infection. Summary of 1925 Greenhouse Tests. (52 seeds planted in each test).

	Total No. of Plants		Percent of Smutted Plants	
LOOSE SMUT	Large	Small	Large	Small
Banner 4707 M. C.				
Test 1	51	46	80.39	80.43
2	50	49	54.00	79.59
3	50	46	62.00	89.13
4	51	46	52.94	89.13
Average	50.5	46.7	62.33	84.57
Alaska 412 M. C.				
Test 1	51	49	23.53	38.77
2	48	48	22.91	33.33
3	51	47	13.72	55.32
4	51	51	19.60	45.09
Average	50.2	48.7	19.94	43.13
Liberty (0.480).				
Test 1	46	50	65.21	86.00
2	45	44	75.55	81.81
3	45	37	33.30	32.43
4	49	48	83.67	95.83
Average	46.2	44.7	64.43	74.02
COVERED SMUT				
Banner 4707 M. C.				
Test 1	42	50	16.66	10.00
2	46	50	8.69	4 00
3	45	51	28.88	17.64
4	44	45	6.81	8.88
Average	44.2	49	15.26	10.13
Alaska 412 M. C.				
Test 1	39	45	25.69	40.00
2	33	35	6.06	20.00
3	42	42	14.28	11.90
4	39	39	38.46	33.33
Average	38.2	40.2	21.12	26.31

TABLE OF CONTENTS

Letter to the Minister of Agriculture 3

List of Officers 5

List of members 5

Financial Statement 1928-1929 8

Report of Annual Meeting 9

Some Chemical Problems involved in the study of insecticides and fungicides—Frank A. Herman 10

Some notes on seed treatments—J. G. Coulson 17

Recent developments in the use of Sulphur Fungicidal Sprays—C. F. Taylor, B.S.A 28

Some advantages of Nicotine Dusting—W. H. Brittain, Ph.D 33

Sulphur as a deterrent to June beetle (Phyllophaga anxia Lec.) Oviposition in Timothy sod—G. H. Hammond 37

Effects of some sulphur sprays on fruit-bud development—C. E. Petch 39

Some studies on the use and action of Bichloride of Mercury as a Fungicide—J. L. Howatt 40

Protection of trees from insects—E. P. Felt, D.Sc 43

Notes on the distribution of the Cyclymen Mite Tarsonemus Palidus Banks—Ala G. Dustan 48

A brief note on the occurence of a mermithid parasite genus Hexamermis, in the Tarnished plant Bug. Lygus Pratensis L.—R. H. Painter 53

Experiment on the value of "Dipdust as a disinfectant for seed potatoes—B. Baribeau 55

The Stem Spot of Onions—J. E. Machacek 58

The effect of Gypsum upon the Growth and common scab of the potato—John G. Coulson— .. 64

A preliminary report on size of seed in relation to smut infection in oats—Emile A. Lods 80